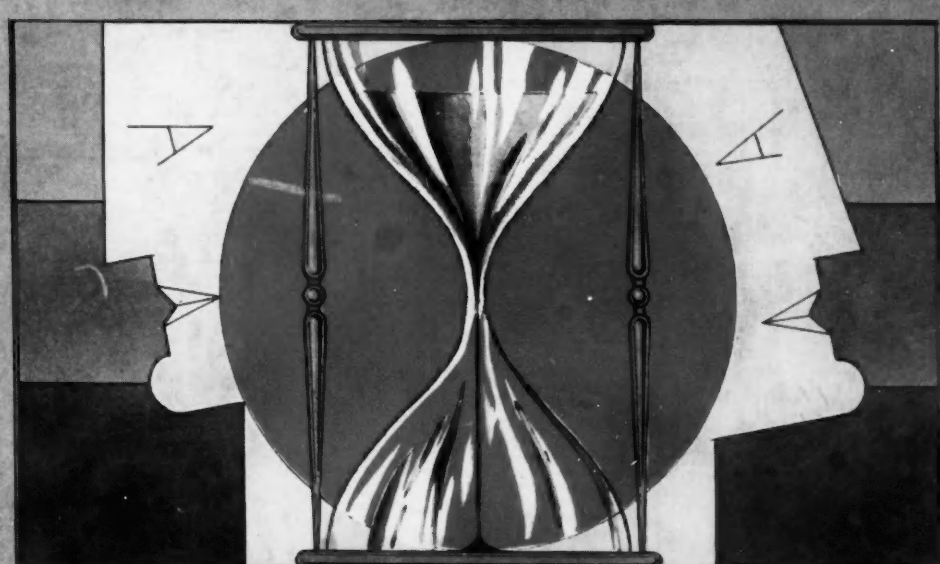
THREE SECTIONS SECTION 1

S·A·E JOURNAL



JANUARY 1931

S·A·E· JOURNAL

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Vol. XXVIII — January, 1931 — No. 1

CONTENTS

The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.

Vol. XXVIII No. 1

S.A.E JOURNAL

January 1931

Published by the Society of Automotive Engineers

S.A.E. Starts New Year Right

January an Eventful Month for Members—Annual Dinner and Three National Meetings Scheduled—Program in Accompanying Supplement

IF IT IS TRUE that "well begun is half done," the Society will be justified in considering itself well along its way toward a year of achievement, before 1931 is a month old, for it is beginning the year very actively by holding the Annual Dinner and three National meetings this month.

The night of Jan. 8 will be S.A.E. night, not only in New York City but also in Miami, Fla. Members who are in the city of the Great White Way on that evening will forsake the bright lights of Broadway and the many attractions of the Automobile Show for a few hours to meet their friends at the Hotel Pennsylvania and hear the brilliant Annual Dinner performers—Toastmaster Kettering, Speaker Knute Rockne and Official Humorist Schermerhorn. Members who are in Miami on that date will turn from the municipal airport and the All-American racers, the palm trees, the white sand beaches and the bathing beauties long enough to attend the Aeronautic Dinner. This will be held at the Columbus Hotel. Some details about the Miami event are given in a following announcement.

Two weeks after the gala events of Jan. 8, New York City will again be the gathering place of automotive engineers for the Motorboat Show and the Motorboat Meeting of the Society on Jan. 22. Advance information regarding the program of this meeting will also be found on a subsequent page in this issue of the S.A.E. JOURNAL.

Comprehensive Annual Meeting Program

The practice, begun last year, of having the Annual Meeting program extend over a five-day period is being continued this year, as a shorter time would not be adequate to accommodate the sessions that must be scheduled to meet the needs of all the members. Details of the meeting program are given in the accompanying Supplement.

Sessions are to begin promptly at the appointed time and be conducted on a predetermined schedule. A definite time limit will be set for each author and there will be a complete understanding between author and session chairman regarding this allowance, so that there will be strict adherence to the schedule and ample time afforded for discussion of the papers presented.

As will be noted in the program Supplement, the Standards Session has been scheduled for the morning of Monday, Jan. 19. A large attendance is expected, as business of importance is to be transacted.

Engine and Body-Session Papers

Two papers to be presented at the Engine Session on Monday afternoon are on topics that will appeal to a large majority of the attending members. E. S. Marks and C. T. Doman, of the H. H. Franklin Mfg. Co., have prepared a paper dealing with the development of a cylinder of the direct air-cooled type which they claim is capable of delivering power output and of dissipating waste heat as well as, if not better than, the indirect or water-cooled type. Features of the design of the various cylinders leading up to the present design are discussed. D. P. Den Hartog and J. G. Baker, of the Westinghouse Electric & Mfg. Co., in their paper on Torsional-Vibration Dampers, discuss the fundamentals of torsional vibration and describe various stress-limiting devices that have been developed. Tests made on a model in the laboratory are described, and the authors have agreed to have the model available for demonstration at the meeting. Alex Taub, of the Chevrolet Motor Co., who will preside at this session, is taking steps to obtain prepared discussion of both papers.

Attention is called to the fact that the chairman of the Body Session, on Monday evening, will be L. Clayton Hill, of Dietrich, Inc. All of the old-timers and all but the newest of the new-timers will quite readily deduce from this item that this particular session will be characterized by unexcelled snap. All who attend this session will enjoy an address by Capt. H. Ledyard Towle, art director of the Campbell-Ewald Co., who can be

Meetings Calendar

National Meetings of the Society

Annual Dinner—Jan. 8

Hotel Pennsylvania, New York City, 6 P.M.

Miami Aeronautic Dinner—Jan. 8

Columbus Hotel, Miami, Fla.

In conjunction with All-American Air Races

Annual Meeting—Jan. 19 to 23

Book-Cadillac Hotel, Detroit

Motorboat Meeting—Jan. 22

Home-Making Center, Grand Central Palace, New York City; Motorboat Luncheon following session

19th National Aeronautic Meeting—April 15 and 16

Book-Cadillac Hotel, Detroit

January Section Meetings

Baltimore—Jan. 21

Lord Baltimore Hotel; Dinner 6:30 P.M.; Entertainment

Free-Wheeling—W. W. Smith, Service Engineer, Studebaker Corp. of America

Buffalo—Jan. 21

Hotel Statler

Oil-Cooling—W. R. Ramsouter, Research Engineer, Harrison Radiator Co.

Canadian—Jan. 21

Royal York Hotel, Toronto; Dinner 6:30 P.M.

Chicago—Jan. 27

Hotel Sherman

Improvements and Various Features of the Current Models Exhibited at the Automobile Show

Cleveland—No Meeting

Detroit—Jan. 22

The Detroit Section will act as Host to the Society at the Annual Meeting Dinner

Indiana—No Meeting

Metropolitan—Jan. 5

Hotel Commodore, New York City; Annual Automobile Show Dinner, 6:30 P.M.; Entertainment

What 1931 Will Bring to Motordom: Engines—A. F. Denham, Chilton Class Journal Co.; Chassis—H. L. Horning, President and General Manager, Waukesha Motor Co.; Bodies—O. T. Kreusser, Fisher Body Corp.

Metropolitan—Jan. 22

Grand Central Palace, New York City. In conjunction with the National Motorboat Meeting

Milwaukee—No Meeting

New England—Jan. 13

Hotel Kenmore, Boston; Dinner 6:45 P.M.

Axle and Wheel Alignment; Their Effect on Tire Wear and Shimmy—Will Dammann, President Bear Mfg. Co.

Northern California—Jan. 8

Athens Athletic Club, Oakland, Calif.

Economies of Motor Transportation with Dual-Drive Trucks—Theodore Bill, Sales Manager, Fageol Motor Co.

Northwest—Jan. 9

New Washington Hotel, Seattle, Wash.

Our Braking Problem—John Wright, Russell Mfg. Co., and several other speakers

Oregon—Jan. 9

Multnomah Hotel, Portland; Dinner 6:30 P.M.

Oregon State College Aeronautical Course—Dean H. S. Rogers

The Air Corps Engineering School at Wright Field Prof. J. C. Othus

Welding from a Metallurgist's Viewpoint—Prof. S. H. Graf

The Aircraft Industry in England—Prof. Walter R. Jones

An airplane fuselage will be presented to the Oregon State College by the Oregon Section at this meeting, and parts and accessories will be exhibited

Philadelphia—No Meeting

Pittsburgh—Jan. 15

Automotive Laboratory, Carnegie Institute of Technology

Brake Forum

Southern California—Jan. 9

Alexandria Hotel, Los Angeles; Dinner 6:30 P.M.; Entertainment

Development of Carburetion and Manifolding—O. H. Ensign, President, Ensign Carburetor Co.

Modern Plain-Tube Carbureters—W. I. Gieske, Stromberg Carburetor Co.

Airplane Carbureters—William Birren, Curtiss-Wright Corp.

Superchargers—Ralph DePalma

St. Louis—No Meeting

Syracuse—No Meeting

Washington—Jan. 28

Wichita—Jan. 8

Metal Aircraft Construction—Frank Smith, General Manager, Buckley Aircraft Co.

counted upon to bring out some very pertinent and valuable material on the subject of design and color as factors in producing and marketing the motor car. Captain Towle is well qualified to talk on this important topic, and the Passenger Body Activity is to be congratulated upon its good fortune in securing him as the speaker at the Body Session.

Practical Fuel-Research Results

Everyone concerned in any way with automobiles is affected by the cooperative fuel-research program that has been carried on for several years at the Bureau of Standards. The results of the most recent phases of this important study will be reported at the Fuel-Research Session on Tuesday morning. The authors and titles of these papers are given in the accompanying Supplement.

The authors of the first of the two papers listed will describe work undertaken with the idea of developing a suitable method for the determination of the gum content of gasoline at the time of test. Comparative data on a variety of gasolines, as determined by a number of methods, will be given. While the investigation has not been completed, sufficient information has been obtained to make possible an analysis of the variables involved, thus suggesting methods of attack that should lead to a more complete understanding of the problem.

The paper discussing current automobile and motorcoach fuel-line temperatures presents some exceedingly practical information, obtained partly from work done by car and coach manufacturers and partly from work done at the Bureau of Standards with cars furnished by the manufacturers. The investigation was therefore thoroughly cooperative in character, covering about 75 per cent of the kinds of car on the road today. J. B. Macauley, of the Chrysler Corp., will be chairman of the session. For additional information regarding this work, see the Automotive Research department in this issue.

On the afternoon of the same day, H. C. Mougey, of the General Motors Corp., will convene the Fuels and Lubricants Session, at which the three interesting papers listed in the program Supplement will be presented. The paper by L. P. Saunders, of the Harrison Radiator Corp., is on a topic that is receiving much attention at present. Because of increased speeds and compression in automobile engines, the problem of oil-cooling has become more and more acute.

The highest high-spot in the Annual Meeting program for many people will be the paper by Dr. R. T. Haslam, of the Standard Oil Co. of New Jersey. Brief articles in the daily press have familiarized engineers and laymen with the term, "hydrogenation process," but it is understood that Dr. Haslam's presentation at the Annual Meeting will be the first public technical exposition of the subject. The material on transmission lubricants, to be presented by C. M. Larson, of the Sinclair Refining Co., comprises interesting and important research data compiled for the S.A.E. transmission-lubricants viscosity numbers.

An evening period has been set aside for the Production Session, because the program that has been planned deserves the largest possible attendance of production engineers and others. The committee, when scheduling the paper on machine-tool obsolescence, was fortunate in persuading L. A. Blackburn, Detroit production executive; J. W. Brussel, of the Timken-Detroit Axle Co., and A. R. Fors, of the Continental Motors Corp., to agree to prepare and present the material. In the other paper to be presented at the Production Session, Prof. Boston and his co-author, Mr. Oxford, have treated in a thoroughly practical way the question of torque, thrust and power values for practical use in drilling cast iron and steel. This is an important topic about which little has hitherto been known. Prof. Boston, who is a recognized authority on this subject, has already discussed it from a theoretical standpoint in a paper delivered at a meeting of another technical society; but in the paper scheduled for the Annual Meeting he concerns himself with the practical aspects of the question.

A Symposium on Detonation

Petroleum engineers as well as those whose chief interest is in cars, either as manufacturers or as operators, will be attracted by the Detonation Session on Wednesday morning, Jan. 21, with R. E. Wilson, of the Standard Oil Co. of Indiana, presiding. Titles of the papers, together with names and connections of the authors, will be found in the Supplement to this issue. The several papers, which are to be presented in abstract form, will consider the effect of various engine factors on the occurrence and intensity of detonation, and the committee expects that this session will make the largest contribution to the question of detonation that has ever been offered at a single meeting. Not only will the progress of the Detonation Subcommittee since its inception in 1928 be told, but the work of the ten cooperating laboratories, including three in England, will be reported.

Transportation and Maintenance Sessions

The transportation men will be occupied throughout Wednesday, as the Transportation and Maintenance Activity is sponsoring a program on the morning of that day and the Motor-Truck and Motorcoach Activity has arranged a program for the same afternoon. The talks at the morning session by D. W. Russell, of the Southwestern Transportation Co., and John B. Walker, of the Greyhound Lines, are expected to bring forth a wealth of valuable information. Warner Tufts, of the National Association of Motor Bus Operators, has agreed to act as chairman of the session.

In the one paper scheduled for the motor-truck session on Wednesday afternoon, at which A. J. Scaife, of the White Motor Co., will be the chairman, J. C. Bennett, of the Associated Oil Co., will present some very practical data, and a lively discussion of both afternoon and morning programs is anticipated.

Interesting Addresses on Aircraft

The Aircraft Session, at which C. B. Fritsche, of the Aircraft Development Corp., will preside, on Wednesday evening, is expected to be an occasion of general interest. Not only will E. R. Armstrong, of the Armstrong Seadrome Development Co., talk on the topic listed in the Supplement, but he will also show a scale model in transparent pyrolin that reveals the design of the inner parts. This model, which can be changed from shallow to deep draft, is illustrative, even to minute details, of what the actual seadrome will be like when finished. Mr. Armstrong's address will be illustrated with lantern slides and by motion pictures showing tests made in Chesapeake Bay with his 32-ft. model.

The aircraft-engine men will have their inning Thursday morning at the Aircraft-Engine Session, at which C. L. Lawrance, of the Wright Aeronautical Corp., will preside. The two papers to be given are listed in the program Supplement. That from the Massachusetts Institute of Technology is on a very timely subject, as it contains data which should be of great interest to those who predict the elimination of the carbureter and component parts in future engines. The paper by P. B. Taylor, of the Wright Aeronautical Corp., will include the results of some very recent investigations made necessary by the demand for constantly increasing horsepowers without consequent additions to engine weight.

Chassis Problems and Diesel Engines

Chassis problems will be given consideration also on Thursday morning, when three papers will be presented at a session at which C. C. Carlton, of the Motor Wheel Corp., will act as chairman. When R. K. Lee, of the Chrysler Corp., discusses some of the rubber problems encountered by the automotive engineer, he will have in his audience many engineers interested chiefly in rubber and many others interested chiefly in cars. It is expected that both types will be represented in the discus-

sion following the presentation of his paper.

What tire engineers think about wheels and rims and what wheel engineers think about rims and tires will be learned from the other two papers at the session, when B. J. Lemon, of the U. S. Rubber Co., will speak for the tire people, and Charles S. Ash, of the Kelsey-Hayes Wheel Corp., will represent the wheel engineers.

Two sessions are devoted to Diesel-engine problems, and the first of them has been scheduled for Thursday afternoon, with O. D. Treiber, of the Treiber Diesel Engine Corp., presiding. E. F. Ruehl, of I. P. Morris & DeLaVergne, Inc., who is the author of the first of the two papers at that session, believes that more attention must be paid to light-weight design and to flexible combustion control if the Diesel engine is to become a serious competitor of the gasoline engine. In his paper he discusses the relative merits of the types of combustion-chamber and injection systems used in present commercial four-cycle engines and continues by describing improvements in design incorporated in a recently developed high-speed four-cycle engine. At the same session, motorcoach operators interested in hearing what has been the actual experience of a fleet operator with Diesel-engined motorcoaches will enjoy listening to the talk to be given by A. A. Lyman, of the Public Service Coordinated Transport.

Detroit Section Host at Dinner

The Detroit Section has announced a superlatively interesting program for Thursday evening, when the Section will act as host to the National Society at a dinner. The central feature of the program, which is to be given by L. A. Hawkins, of the General Electric Co., has been aptly described as a demonstration of the impossible. Members who plan to attend that dinner are hereby warned that the stories they will tell about it afterward probably will not be believed.

The price of tickets for the dinner is $4 each. Requests for tickets, accompanied by check, should be mailed immediately to the Detroit Section office, 2-136 General Motors Building, Detroit.

Riding Comfort and Highway Safety

At the General Development Session on Friday morning E. S. Marks, of the H. H. Franklin Mfg. Co., will occupy the chair. The paper by R. M. Curts, of the New Jersey Zinc Co., listed in the Supplement, briefly reviews the part that zinc and its alloys have played in the past and discusses recent developments in zinc-base alloys that have greatly enlarged their field of use in the automobile industry. The papers by Dr. Fred A. Moss, of George Washington University, and Dr. Ammon Swope, of Purdue University, will tell of the progress made since the Summer Meeting of 1930 in the riding-comfort studies pursued under their direction.

Also on Friday morning, the second of the two Diesel-engine sessions will be staged, with Dr. W. F. Joachim, of the Westinghouse Electric & Mfg. Co., functioning as chairman. E. T. Vincent, of the Continental Motors Corp., will describe interesting research that he has conducted, and C. G. A. Rosen, of the Caterpillar Tractor Co., will present a comprehensive and informative survey of mobile-type Diesel engines.

The culminating feature of the meeting will be at the General Session on Friday afternoon, when Robbins B. Stoeckel, Commissioner of Motor-Vehicles for the State of Connecticut, will talk on a subject of interest to all connected with the automotive industry. Dr. Miller McClintock, who will preside, is director of the Albert Russel Erskine Bureau for Street-Traffic Research. Commissioner Stoeckel is to discuss the responsibilities that rest with engineers and manufacturers who desire to incorporate in their vehicles the utmost in safety.

Six of the Society's eight Professional Activities are to hold short business sessions during the Annual Meeting, as shown in the accompanying Supplement. These meetings are called for the purpose of selecting nominating committees for the respective Activities. A short business session of the Society will be held Monday evening, Jan. 19, at 8 o'clock, immediately preceding the Body Session.

New York Motorboat Meeting

Engines and Installation To Be Discussed Jan. 22 During Motorboat Show

THIS YEAR'S National Motorboat Meeting will be held as usual in connection with the Motorboat Show at the Grand Central Palace, New York City, on Thursday, Jan. 22, in the Auditorium of the Home-Making Center.

The meeting will be under the direction of the Metropolitan Section, which so successfully conducted the Motorboat Meeting a year ago. The program will consist of one technical session, at which three technical papers are to be presented, followed by the Motorboat Luncheon.

Because of the controversy that has continuously existed regarding engine development, particularly as to whether a converted automobile engine or a specially designed marine engine is best suited for motorboat use, it has been decided to provide an opportunity for discussion of this subject by the presentation of one paper by an exponent of each type. A third paper will deal with installation problems.

R. H. Garrison, of the Universal Motor Co., will present the argument for the specially designed engine in a paper entitled, Engines Designed for Marine Use Only. The case for the converted automobile engine will be given in a paper by H. T. Woolson, of the Chrysler Corp., entitled, Converted Automobile Engines for Marine Use. One of the best known of the marine constructors has been chosen for the paper on installation. He is A. E. Luders, of the Luders Marine Construction Co., and his subject is, Fitting the Boat to the Engine, or the Boat Builder's Installation Problems.

Motorboat Luncheon and Show

The technical session will be followed immediately by a Motorboat Luncheon in the dining room of the Home-Making Center adjacent to the auditorium. Tickets to the Motorboat Show will be furnished to those attending the luncheon, the price of which is $1.25 per cover.

The Society is arranging to have a booth at the show in which will be exhibited an engine from the Universal Motor Co. and one from the Chrysler Corp., illustrative of the papers presented at the technical session. The exhibit will be primarily a display of the application of S.A.E. Standards to marine-engine and boat parts. It will indicate those parts of the engine shown to which S.A.E. Standards apply. In addition, it is anticipated that spark-plugs, propellers, shafts, couplings and similar parts will be exhibited to demonstrate the application of the various S.A.E. Standards and Recommended Practices.

Two Aeronautic Meetings

MIAMI will again be the scene of the All-American Air Races at the municipal airport in Miami, Fla., from Jan. 8 to 10, inclusive. The Society's activities this year in connection with this race meet will be a joint aircraft-dinner with the Greater Miami Industrial Association in conjunction with the Aeronautical Chamber of Commerce of America.

This dinner will be held at the Co-

(Concluded on p. 116)

Commercial-Airship Progress Presented

Distinguished Guests and Members of Washington Section Given Pictorial and Oral Treat—Also Told about Piston-Ring Art

"THEY LOOK like pigs," remarked several persons as a slide flashed on the screen. And they did, as they nestled with their bellies close to the ground, their smooth round sides almost touching each other. But they were not. They were babes of the air, a fleet of Goodyear blimps. In the Rose Room of the Washington Hotel, high above the twinkling lights of our Nation's capital, Dr. Karl Arnstein, vice-president and chief engineer of the Goodyear-Zeppelin Corp., was stirring men's minds at the meeting of the Washington Section on Dec. 15 with the possibilities of lighter-than-air transportation, past, present and future.

Visions of an aerial merchant marine were in the minds of the distinguished guests and the 150 others who attended the meeting. Honored guests were William P. McCracken, Jr., formerly Assistant Secretary of Commerce for aeronautics, who served as toastmaster; John A. C. Warner, General Manager of the Society; the Hon. David S. Ingalls, Assistant Secretary of the Navy for aeronautics; the Hon. Clarence H. Young, Assistant Secretary of Commerce for aeronautics; the Hon. Hiram Bingham, United States Senator and president of the National Aeronautical Association; Capt. John H. Towers, assistant chief of the Bureau of Aeronautics; Col. A. B. Barber, chief of the transportation division of the United States Chamber of Commerce; and Dr. George W. Lewis, director of research for the National Advisory Committee for Aeronautics. Also present were Dr. H. L. Dryden, chief of the aerodynamical research section, Dr. H. C. Dickinson, of the heat and power division, and H. K. Cummings, in charge of the aeronautic engine test work, all of the Bureau of Standards; and Congressman Siberly, of Ohio, and Major Davidson, U.S.A., commander at Bolling Field.

About 85 members and guests attended the squab dinner, which not only satisfied the palate but provided a variety of feasts for the eyes and soothing songs by Dorothy Skinner. After dinner, Toastmaster McCracken introduced each of the distinguished guests, who arose and made a bow.

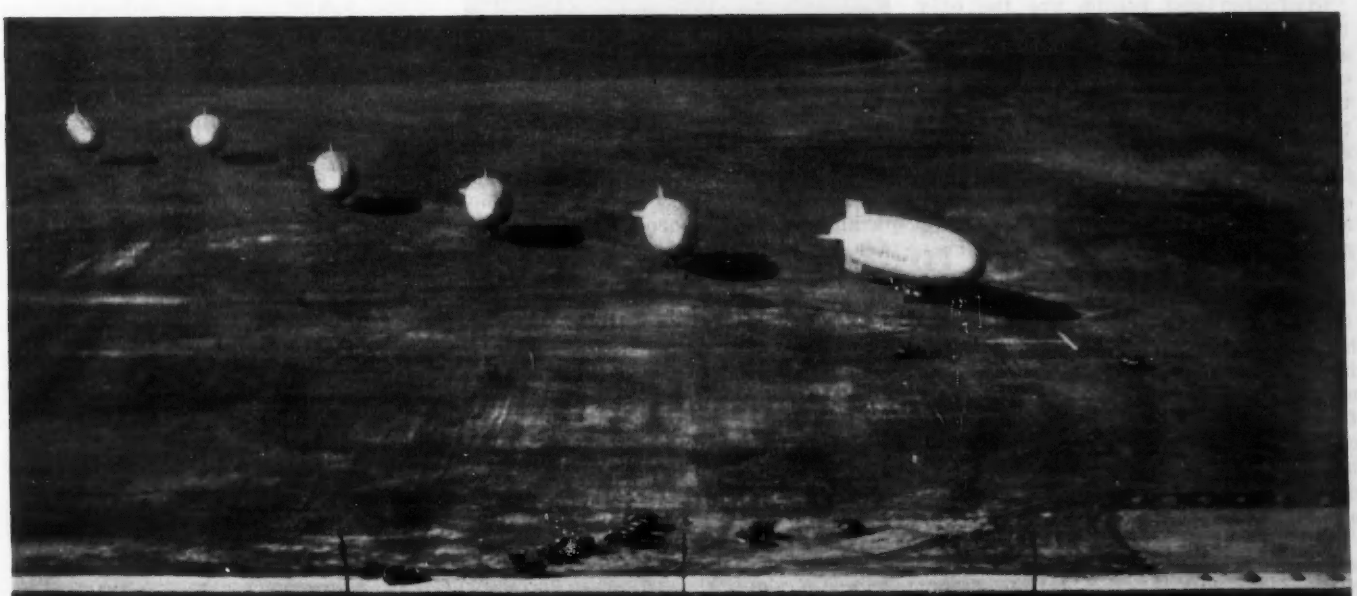
How Visions Become Realities

Since the Graf Zeppelin's memorable flight around the world and trips over the Mediterranean and various parts of Europe, the possibilities of the airship have been much in the public mind, Mr. McCracken said, introducing as the first speaker Dr. Karl Arnstein, who he said has devoted his entire life to the study of lighter-than-air craft, is internationally known and has been honored with degrees from many universities. He was formerly chief engineer of the Zeppelin works in Germany but is now a full-fledged American citizen who has voted.

All complex machines and mechanical contrivances develop in three stages, began Dr. Arnstein. First there is a vision in a man's mind, an imaginary possibility. Second, there is a cutting and trying of apparatus in an effort to get one that will fulfill the inventor's vision. During this stage the public hears something of the inventor and his crazy ideas and speculates as to whether the inventor should be confined to an asylum. But if the inventor escapes the asylum and finds a means of producing a practical machine, then capital is attracted to the idea and thus convinces the public that the asylum can get along without the inventor. Laboratories are then supplied and scientists put to work to determine the fundamental principles of the machine.

However, it is an exceptional invention that develops without suffering reverses. Though the present airships have been greatly refined, much more research needs to be done, as the design of lighter-than-air craft embraces so many fields of engineering. Mass-production methods can be employed to only a limited extent, as airship builders are primarily concerned with the construction of single ships of tremendous size.

Count Zeppelin, after demonstrating



"THEY LOOK LIKE PIGS BUT AREN'T"
A Drove or Flock (?) of Small Dirigibles Built at Akron, Ohio, for the United States Navy

that the principles of his invention were sound, gathered about him a body of engineers and each ship since built has embodied improvements over previous ships.

Low-powered ships are economical of fuel but cannot ride through severe storms, continued the speaker. Mayback engines are at present the most suitable for use in airships. Their weight is approximately 4 lb. per hp., and their fuel consmption 0.45 lb. per hp-hr. While the engines seem somewhat heavy their extra weight more than pays for itself in added reliability and fuel economy.

Flexible Bulkheads and New Cell Materials

The latest type of hull construction uses main frames of triangular section and flexible bulkheads between the individual gas cells. The flexible bulkhead serves to eliminate undue strain on the frame if one of the gas cells becomes deflated.

The problem of suitable material for the gas cells is important. The only suitable material for a long time was cotton cloth covered with gold-beaters' skins. This made satisfactory gas bags but the skins were very expensive and difficult to manufacture. Research has since developed a rubberized-fabric cell and a gelatine-latex cell both of which are satisfactory. The rubberized cells are somewhat heavy but are inexpensive and will stand rough handling. The gelatine-latex cells have characteristics very similar to those of the cells formed from gold-beaters' skins, are less expensive to manufacture and seem to be well on the way toward displacing skin cells.

Lifting Gas and Fuel Gas

Hydrogen and helium are the only two gases that are commercially possible for airship use. The fire hazard of hydrogen-inflated ships is so great that it is doubtful if the public would patronize ships that used it, said Dr. Arnstein. Helium has less lifting power than hydrogen but has advantages that more than offset this shortcoming. Helium ships may safely carry the powerplants within the hull, thus cutting down the drag of the ship and increasing its speed.

Extra lift may be obtained with the helium by using up to 10 per cent of hydrogen with it and still have an absolutely fireproof mixture. The case for helium seems to Dr. Arnstein exceedingly strong here in America and he doubts if we shall ever build hydrogen ships so long as helium is available.

The use of an inflammable gas for engine fuel presents a fire hazard in a helium ship but this could be greatly reduced by completely surrounding fuel gas with helium. Some possibility exists, continued Dr. Arnstein, of developing a fuel gas that will be non-inflammable at ordinary pressures but which will ignite when under compression in the engine. Fuel gas is more economical to burn that gasoline, developing 1 hp.-hr. on about 0.4 lb. of fuel gas as against 0.45 lb. of gasoline.

Airships today are built on the triple-layer principle. The gas cells form the inner unit and furnish the lifting power; the metal framework is the intermediate unit and takes all stresses; over the frame is stretched doped fabric which gives protection from the elements and presents a smooth surface.

Doped Fabric Covering Believed Best

Doped fabric is considered the best outer covering material, being waterproof, strong and durable. Metal coverings have been suggested but tear easily and add unnecessary weight, according to the speaker. He also

DR. KARL ARNSTEIN

quoted Colonel Richmond, of the ill-fated R-101, as saying that corrosion of the thin metal covering is comparable with the normal deterioration of a doped covering, while the repairing and maintenance of an all-metal ship would be more difficult than for one covered with a doped fabric.

Downward forces when flying in rain result from three causes: (*a*) direct impact of rain drops, (*b*) added weight of a coating of water, and (*c*) absorption of water by the fabric parts. The force of impact is regarded as negligible, being calculated as about 300 lb. on a ship the size of the R-101 when a heavy rain is falling. A film on the surface of the R-101 would probably not weigh more than 6 tons, whereas a ship of that size should be able to carry at least 15 tons of rain merely by flying at a greater angle of pitch.

The moisture is not absorbed on the outside but on the inside of the fabric covering and in the material of the gas cells. The fabric always contains some of this absorbed moisture, and the total increase in wet weather for a ship the size of the R-101 should be less than 1 ton.

The United States Navy Department has contributed more to the art of handling airships than have all other interests, asserted Dr. Arnstein. The large ground crews that have always been necessary in the past will soon be supplanted by mechanical devices that will handle the airships with ease and precision.

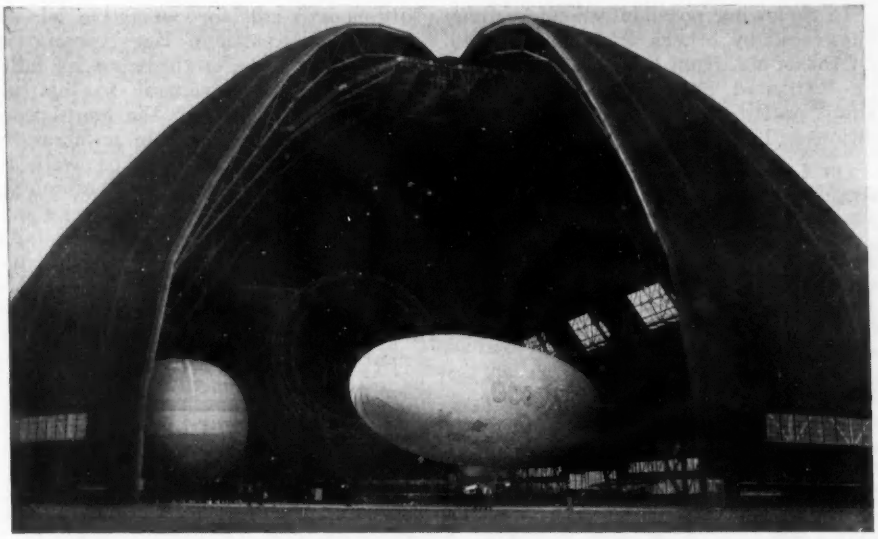
Traveling by airship offers comforts that are not possible with other means of travel. There is no engine noise, no pitching and rolling and no dust and dirt. Spacious accommodations are provided, some airships even being equipped with shower baths. In addition, there seems to be a total lack of seasickness among passengers. The high speeds of the present-day ships enable them to fly through any ordinary storm, and it is possible to go over or around others. The spacious quarters permit the installation of elaborate radio and navigation equipment, and the engines are always accessible because of the triple-layer construction and the passages through the ten main frames.

Travel by Airship Not New

Travel by airship is not an innovation. From 1911 to 1914 a German company carried more than 34,000 passengers in addition to a quantity of mail. During the first 11 months of 1930 the Graf Zeppelin flew 144,000 miles, carried more than 6000 passengers and more than 2,000,000 pieces of mail.

The public has been somewhat unfavorably impressed with airship travel because of the emphasis that newspapers have placed upon catastrophies. Most of the accidents, however, have been in connection with initial experiments by nations anxious to acquire the art of airship building. The British R-38 failed because of lack of construction knowledge and experience. The inexperience of both the builders and the crew of the R-101, together with the use of hydrogen, was largely responsible for its appalling end. Yet each new ship built embodies the result of further research and experiment, added to the knowledge and experience of the past. The official British report on the R-101 disaster stated that faulty design and management were responsible rather than any inherent faults in the airship as a type.

The recent report of our National Advisory Committee for Aeronautics to the Congress now in session stated that probably the use of hydrogen in the R-101 was responsible for the loss of life but that our natural resources of helium should give the United States



GOODYEAR-ZEPPELIN AIRSHIP DOCK AT AKRON

The Great Revolving Doors Are Opened To Expose to View the Framework of the 6,500,000-Cu. Ft. Airship under Construction for the Navy and a Small Semi-Rigid and a Free Balloon

a decided advantage in airship operation. The committee recommended that the airships in this Country should be thoroughly developed and demonstrated and that "airship lines should be established on a basis that will give to the United States an airship merchant marine."

Petre Tells of Piston-Ring Art

Hemp rope, wood, rubber and bronze have all been used as piston-ring material, remarked A. Preston Petre, research engineer of the American Hammered Piston Ring Co., in an address on Piston Ring Manufacture and Progress. While the piston-ring is a seemingly small part of an engine, it must withstand extreme heat and high gas pressures as well as the constant wear on the cylinder-wall, must provide a gas seal and prevent excessive oil consumption.

Gray cast-iron seems to be the only satisfactory material, after a great many trials of other materials. Close-grained cast-iron has high tensile strength great resistance to impact and abrasion, and is exceedingly resilient when subjected to stressing.

When choosing piston-rings for an engine, the engine design and the conditions of operation must be considered. In aircraft engines, most of which use a large piston clearance, narrow piston-rings together with a plain or beveled oil-ring, seem to be most satisfactory. High-speed automobile engines use moderately narrow rings and frequently operate with only two compression-rings and one oil-ring. Multipiece rings are often used in worn cylinders or in Diesel engines where other rings fail to form a good seal.

Tests of various kinds have been developed to determine leakage, wear and heat dissipation. In many engines the heat dissipated through the ring section of the piston is about 60 per cent of that absorbed by the piston. Leakage is determined in cubic feet per minute for both static and running conditions, using a piston clearance of about 0.01 in. The step-joint ring makes a better seal than the bevel-cut ring, said Mr. Petre.

Audible blow-by to the crankcase is nearly always caused by fitting the top ring of the piston too tightly. This ring receives less lubrication and more heat than any of the others. In Diesel engines the pressures are so great that sometimes the top ring-groove will be hammered together. Replacement rings for this groove often have to be narrower than the original rings used.

Ring flutter sometimes occurs at speeds above 4000 r.p.m. and allows leakage of gas and oil-throwing through the breather of the engine. Ring breakage is often caused by not allowing sufficient clearance between the two ends of the ring. Worn pistons and loose piston-fits also cause ring breakage.

Service tests are the most reliable for determining wear, though this is a tedious method. Wear is measured by the joint clearance of the ring before and after running, the measurements being taken while the ring is in the cylinder. If the cylinder contact surface of the rings becomes worn round, the ring will neither seal against compression nor oil.

Early manufacturing methods consisted in merely machining a round pot or drum casting, sawing off a ring with a hacksaw, cutting out a gap and guessing at the tension. Present rings are manufactured by the company Mr. Petre represents from individual castings machined all over and then mechanically hammered to equalize the tension. The analysis and properties of the cast iron used are carefully determined and controlled.

Tensile strength should be above 30,000 lb. per sq. in., the Rockwell hardness 95 and 100, and the Brinell hardness about 200. The hardness of the cast-iron is very important and great care is taken in casting to assure the right analysis. The silicon and nickel contents are closely watched. The heat dissipation in the mold after casting greatly influences the properties of the casting. Gray cast-iron cannot be compared with steel when viewing the two from a piston-ring manufacturer's stand, said Mr. Petre, and the term semi-steel is a misnomer.

Good Piston-rings depend largely upon the analysis, hardness and structure of the cast-iron from which they are made, and although rings are manufactured by engineers and not founders, enough is known about the three subjects to produce rings that are acceptable to all of the engine manufacturers in the Country, both large and small. More than 10,000 types and sizes of rings are made each year.

After the papers had been delivered, three reels of motion pictures of airship design, manufacture and operation were shown.

Patent System Criticized

Hunt Tells Philadelphia Section How Present Practice Hamstrings Industry, and Proposes Remedies

APPROXIMATELY 100 members and guests of the Philadelphia Section enjoyed the privilege of listening to what may be an epoch-making address at their monthly meeting on Dec. 10. The speaker was J. H. Hunt, of the patent division of the General Motors Corp., and his subject was The Automobile Industry and the American Patent Situation.

If, in the next few years, Mr. Hunt's address is seen as the opening gun of a battle to rectify the abuses and weaknesses of the present patent regulations, and if it has received the backing of the Society, then indeed this address can be termed "epoch-making." Mr. Hunt expressed the view that no good reason exists why the automotive engineers should not officially lend their influence in clarifying the patent situation so that the public, the manufacturer and the inventor shall each receive proper benefit.

Complications Hypothetically Pictured

Present regulations give rise to delays, uncertainties, losses and, at times, actual miscarriage of justice. Probably few persons who are not actively engaged in patent work know to what extent these are possible and the mechanisms through which they can occur. These were clearly portrayed by the speaker in the history of a hypothetical case in which a car manufacturer, several inventors and a rather shady company dealing in patents became involved in a snarl of litigation that out-complicated the complications of the modern mystery or detective story. The final chapter of this history has not yet been written, but, unlike the popular story, it looks as if the "villain" will finally eat the bacon.

In his preamble, Mr. Hunt explained that all the various interference and infringement proceedings illustrated in his story had not occurred simultaneously in any one instance, to his best knowledge, but that they had all occurred singly or in some groupings in actual cases.

The illustration hinges around an automobile manufacturer who purchases a patent in good faith, commercializes and advertises it successfully, and then falls afoul of an infringement suit by a company that deals in old patents. The infringement is based upon a rather cleverly worded claim of a patent unrelated to the automobile industry. Investigation disclosed that this claim had been allowed only a short time prior to the suit and had apparently been worded so as to make the suit possible. It was not in existence when the automobile company's preliminary patent search was made. The patent had been filed years before and kept in the Patent Office, unissued, by the various subterfuges which present regulations make possible.

As a result, the manufacturer was placed in a rather serious position, for he could not be the aggressor in the subsequent proceedings; he could only defend the suit brought against him when and where the plaintiff desired. As courts in different districts adjudge patent rights differently on the same evidence, the eventual outcome of the case is somewhat doubtful even though the manufacturer is made the victim of a shady but carefully planned attack.

This one instance illustrates, said Mr. Hunt, several of the glaring faults in our patent procedure that make possible such a condition. Among these are overly long secret proceedings in the Patent Office; overcrowding in the Patent Office, which makes impossible the efficient examination of patent claims by the examiner; lack of knowledge of commercial art on the part of examiners in deciding whether a patent actually is an invention; lack of uniform judicial decisions in patent litigation.

In reviewing possible remedies, many suggested by others were enumerated. Of these, Mr. Hunt believes four should be instituted as soon as possible to adapt patent procedure to modern conditions. These are:

(1) Limit the period of secret proceedings in the Patent Office to a definite period not greater than three years.

(2) Provide that the latest expiration date of a patent shall be not more than 20 years after date of application.

(3) Grant patents to the first applicants and settle the question of interference later, without delaying the issue.

(4) Provide a single Court of Patent Appeals, the judges being required to have a technical training.

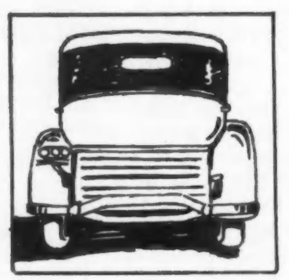
These modifications of patent regulations will call for corrective legislation. The American Bar Association, Mr. Hunt stated, is throwing its influence into the movement to institute such modificatinos of the regulations that the patent snarl can be straightened out. Would it not be well, he asked, for the Society of Automotive Engineers also to officially give its support to this movement? Mr. Hunt did not specifically make that plea, but undoubtedly that thought entered the minds of many who were listening to him. The fruits of the successful culmination of such a movement should be of great value to the automotive industry, to other industries having national distribution, and to the individual inventor as well.

World Car Bodies Compared

Rippingille and Northup Contrast European and American Design for Detroit Section

HOW national characteristics are reflected in automobile bodies and what the American visitor to the Paris Salon this year saw that was of special interest were told to several hundred members and guests of the Detroit Section at its body meeting on Dec. 8 by E. V. Rippingille and Amos Northup respectively. H. R. Crecelius, Chairman of the Section, and A. J. Neerken, Chairman of the Body Division Meetings Committee, presided at the double session.

Mr. Rippingille, who returned to Detroit last year from an extended stay in Europe for the General Motors Export Co., gave a long, interesting, informative and amusing talk about body styles and workmanship abroad as contrasted with American bodies. He pointed out that the differences that seem amusing to the visitor from the United States and the designs that would not be acceptable here are suited to the temperament of the peoples and the conditions in European countries. For example, the English people are scientifically and mechanically minded, and if the English automobile bodies are examined and the origin of the various types is traced through the years, one will find that a great deal of attention has been paid to the construction and that the bodies have been fitted well to the human form. Leather upholstery predominates because of the wet climate and the fact that the motorists ride even in summer with a raincoat on. The cars have a lot of pockets and trick compartments, because the owners want places to stow tools and various odds and ends which are an important part of the equipment. "Rip" said in part:



In America, where there is a garage or service station in almost every block, we don't need to carry a tool-kit, and the American driver doesn't think about that sort of thing; he has no desire to take the float out of the carbureter and play with it by the side of the road, but I give you my word of honor that the Englishmen actually discuss the accessibility of the float chamber and keep a little screw-driver and little nickel-plated pair of pliers and a monkey-wrench all shined up in a side pocket of the car. Even the women like to take a car apart. You can't get that out of a nation; it will take generations and generations to bring them to the same frame of mind we are in with reference to the treatment of automobiles.

How National Characteristics Crop Out

The English have shown considerable ingenuity in their treatment of the top of closed bodies. The average English car has almost the same feeling as an open car because of the extremely light weight of the structure above the belt line. Thick, heavy tops are not needed, because strong, hot sunshine does not beat down in the British Isles as it does here, and climatic conditions are not so extreme as in America, where cars are built to be shipped to Minnesota or Florida.

Mr. Rippingille couldn't say much for the beauty of the English bodies, which he thinks has been sacrificed to scientific construction, but just across the Channel the French automobiles have lines that are artistic and express the French dash and snap. They also

have more elaborate upholstery, but, paradoxically, have some nuts or bolts or something of the sort sticking out, as a sort of last thought, against some beautiful lines.

The Italians usually go in for beautifully chased hardware, beautiful moldings and instrument panels. They seem to have taken the scientific construction of the English and the artistic lines of the French and dressed up the little details.

Temperament of the Germans is more solid, and this is expressed in the German bodies, which are not as sound scientifically as the English bodies but look sounder because to the inexperienced they look more solid, and the German is prone to believe what he sees. One of the primary requirements in a German body is that it have lots of room. Possibly the affluent class that is able to purchase automobiles runs a little more toward waist line and size and therefore need more room.

Scandinavian peoples are practical minded and seem to like anything we ship them, continued the speaker, but they like to put into the cars some flossy upholstering with some bits of red in it. With that addition, they are perfectly satisfied if the car gives them good service.

Another important difference is the attitude toward automobiles in Europe and America. Over there, they are not so commonplace and are largely used for the pleasure of riding, whereas in this Country, "we use them to get some place and see what we can find in the icebox. We leave them out on the street and they never seem to get washed."

Mr. Rippingille contrasted body engineering on the two sides of the Atlantic to the credit of America, saying that the European does not have the resources that American companies have and the fine exteriors cover up a lot of crude work. The bodies in general are not well built. In the bracing of the body and in general construction, "we can give the European builders points any time, and they are trying to discover how we can build them so well and so light and cheaply." However, Mr. Rippingille had some good words to say for the individuality of the European product, which is a characteristic that he thinks we need in America today.

High-Lights of the Paris Salon

According to Amos Northup, of the Murray Corp. of America, the Paris Salon of last November was of more interest to the American visitor than ever before because the European standards of beauty in automobile design closely resembled our own. However, some features of the European bodies were entirely different in principle from our own. For instance, almost without exception, belt moldings were finished in chromium-plating. Several all-metal roofs were in evidence at the Salon. The use of metal makes an extremely beautiful roof and is of importance with the low cars so prevalent today.

A feature of interest to the engineers as well as the designer was the absence of drip moldings. An examination of the cross-section of the door-headers and roof-rails of these bodies showed that they were not necessary to keep the dripping water out of the body.

The front end of the front fenders is brought much lower toward the ground than in this Country; in fact, they cover more than half the tires. This hides the front mechanism of the chassis and makes a better-looking car.

A few departures from the conventional turnunder were observed by Mr. Northup. One car had side surfaces that were vertically straight, permitting the use of a continuous hinge on the doors, running practically the full height of the door. Another had the curve of the turnunder extended clear down to the running-board; while on still another the lower surface of the body below the belt was made concave instead of having the usual turnunder.

The major trend in windshields seemed to be toward slanting and stationary types. Radiator screens were very popular. One car had thin vertical bars finished in chromium and fastened to the radiator like a screen.

Voltage Control of Generators

Pittsburgh Section Comments on Generator Regulation Described and Demonstrated by M. A. Eason

MORE than 100 members and guests of the Pittsburgh Section listened with interest to the explanation of the action of voltage-control regulation of generators as given by M. A. Eason, field engineer of the Leece-Neville Co., at a dinner meeting held at the Hotel Schenley on Dec. 11. Music and entertainment were provided by Bill Davis and his orchestra.

Vice-Chairman B. H. Eaton, of the Bell Telephone Co. of Pennsylvania, acting as chairman, introduced the first speaker, A. C. Rankin, of the Pittsburgh *Sun-Telegraph*.

Mr. Rankin spoke on the relation between newspapers and the automotive industry, saying that "the engineers create news, and the newspapers publish it." He compared the relation between engineers and the newspapers with a reunion between Henry Ford and Barney Oldfield, when Mr. Ford said, "Well, Barney, you made me and I made you"; to which Barney aptly replied, "But I made a better job of it than you did."

Contrary to public opinion, continued Mr. Rankin, the newspaper has to be alert and to "take chances" on news, as the time is too short to verify the wide variety of material that is part of the daily grist. The modern newspaper, with its high-speed presses and huge circulation, is rapidly creating a production problem that will require handling by the engineering type of mind. He also pointed out that Pittsburgh is the center of the iron and steel industry, of bridge building and glass manufacture, and of electrical and other industries, and may therefore well lay claim to being one of the great engineering centers of the world.

Speaking of the advantages of voltage regulation as a method of generator control, Mr. Eason said that we are prone to forget that the usual automotive engine consumes at least 1 pint of gasoline per horsepower-hour, and that a car or truck generator charging at a constant rate of 15 amp. or more may easily consume 1 hp. through belt or gear drive, friction, heating and electrical losses.

Constant-voltage regulation cuts down the charging rate as the battery becomes charged, resulting in appreciable fuel savings. "No battery is ever damaged by charging it, until it is fully charged," he said. The damage occurs after continued charging at a high rate has boiled away the electrolyte until the solution is below the level of the plates. Demonstration apparatus gave a clear conception of the action of voltage control under varying conditions.

Mr. Eason then described some recent developments in generators, including a 2600-watt generator for aviation use that weighs only 42 lb. and is capable of producing 1000 volts, for use on the plate circuits of aviation radio-sending sets.

Lantern slides showed the various locations of the landing-lights on airplanes, on upper or lower wings or on the fuselage.

Eason Answers Discussers' Questions

A spirited discussion followed the assertion that "battery ignition is best for internal-combustion engines." Some

of the questions and answers were as follows:

QUESTION:—Why is mangeto ignition used so extensively on airplanes, where reliability and weight are so important?

ANSWER:—Aircraft engines are not yet built on a large - production basis, hence the makers of battery ignition-systems hardly find it profitable to tool up for aviation ignition apparatus. But a battery has to be carried for landing and other lights for night flying. Then battery ignition weighs less, because the weight of a distributor is less than that of a magneto.

QUESTION:—Is any trouble caused by sticking of the points of a voltage regulator?

ANSWER:—One point is made of silver and the other of platinum, giving a difference in welding temperatures of more than 1000 deg. fahr. and eliminating the possibility of sticking.

QUESTION:—In case of a battery failure, with plates buckled and disintegrated, what would you surmise was the cause?

ANSWER:—Too high voltage, resulting in too high a charging rate after the battery had been fully charged; rapid discharging by prolonged use of the starter; or mechanics short-circuiting the battery with pliers.

QUESTION:—How does the voltage regulator operate?

ANSWER:—The blade operates at 2600 vibrations per minute, irrespective of generator speed, and introduces a fixed resistance into the shunt winding of the compound-wound generator. The resistance is predetermined to meet individual conditions.

QUESTION:—If the battery of the average car or truck, having third-brush regulation, is fully discharged, can it be recharged with the generator on the car?

ANSWER:—Yes, provided one can get enough current for ignition to start the engine while using the hand crank and if the engine is run long enough before the next stop to put sufficient current in the battery to restart the engine with the starting motor.

QUESTION:—How often should voltage regulators be inspected or checked?

ANSWER:—An inspection every 5000 miles on trucks and motorcoaches, where reliability is so important, is a wise precaution.

QUESTION:—When adjusting voltage regulators, does the internal resistance of the battery, as affected by wood or rubber separators, make any difference?

ANSWER:—It makes no appreciable difference with any of the standard makes of battery.

QUESTION:—What effect does the use of voltage control have on selection of the capacity of the generator?

ANSWER:—Sometimes it may be necessary to operate the car with the battery removed, hence the generator should be of sufficient capacity to carry the entire load, less the starter current and the battery-charging rate.

QUESTION:—What relation is there between the size of the battery that can be used with voltage-controlled and that used with third-brush-regulated generators?

ANSWER:—A smaller battery can be used with voltage regulation, provided the battery is of sufficient capacity for operating the starter and for use when the engine is not running. Battery life is longer with voltage regulation, because the ampere rate of charge is reduced as the battery becomes fully charged.

QUESTION:—What is the difference in initial cost between the voltage-control and third-brush types of generator?

ANSWER:—The only difference in cost is between a circuit breaker and a voltage regulator. The generator cost is the same.

Golden Gate Christmas Party

Impromptu Talks, Dinner, Entertainment and Technical Session Please North Californians

WELDING was the appropriate subject of the one technical paper presented at the Christmas Party of the Northern California Section held at the Engineers Club in San Francisco on Dec. 11, at which the professional friendships of the members were more firmly welded. A very representative gathering of about 60 members partook of the dinner and enjoyed the entertainment provided. Vice-Chairman Howard Baxter, from Oakland, pinch-hitting for Vice-Chairman Carl Abell, in charge of the East Bay contingent, had his usually strong representation with him. He had his cohorts rise en masse to make an impression by their numerical strength.

Numerous impromptu talks were given at the dinner, at which Chairman E. H. Zeitfuchs presided. Prof. A. H. Hoffman, of the University of California, talked about Christmas cheer and the activities at the University in Davis. Chairman Horace Hirschler, of the Membership Committee, called the roll and the members present rose as their names and company connections were announced. E. W. Carroll, of the Kalif Corp., a new member, was introduced.

After dinner, the members adjourned to the social hall for a brief period of social intercourse, and then returned to the auditorium for the business meeting and technical session. Chairman Zeitfuchs officiated, minutes of the November meeting were read, and Mr. Hirschler, chairman of a committee in charge of the joint meeting of the Western Metal Congress to be held the week of Feb. 16, gave some brief details of this Congress. The S.A.E. Section will take two days of this Congress, or four sessions. There will be an extensive display at the Civic Auditorium, and the sessions for the presentation of papers will be held at the St. Francis Hotel.

B. H. EATON
Vice-Chairman, Pittsburgh Section

CLYDE C. MATHIS
Chairman of Program Committee, Pittsburgh Section

Details of Welding Told

Mr. Zeitfuchs then turned the meeting over to John R. MacGregor, in charge of the technical session, who introduced as the speaker of the evening, Prof. Nairne F. Ward, of the University of California and lecturer at the Boeing School of Aeronautics. The speaker's topic was Some Theories and Practices in Aircraft and Automobile Welding. The paper went into details as to the various forms of gas welding, resistance welding and electric welding. Slides were shown of various cross-sections before and after making a weld and the proper procedure to be followed. Professor Ward also went into detail as to the welds necessary on an airplane.

Prepared discussion of the paper was presented by L. M. Luchenbaugh, metallurgical engineer of the Standard Oil Co. of California, who went into much detail regarding the procedure in the various welding operations at the company's refinery. He is a strong enthusiast of electric welding, as he believes this to be most satisfactory for the type of work done at the refinery in Richmond, Calif., where a cross rod is used with a flux. Cross-sections of the weld showed that the material after the weld was of much the same structure as the original metal, thus giving a very strong weld.

After considerably more discussion, the meeting was adjourned, with Christmas greetings to all, until the Jan. 8 meeting, which is to be held at the Athens Athletic Club, in Oakland. The speaker will be Theodore Bill, sales manager of the Fageol Motor Co., whose topic is, Economies of Motor Transportation with Dual-Drive Trucks.

Christmas Spirit Pervades Canadian Meeting

YULETIDE spirit reigned at the meeting of the Canadian Section at the Royal York Hotel, Toronto, on Dec. 17. When the hundred-odd members and guests assembled for the Christmas dinner, it was evident that the newly appointed Reception Committee had been functioning, and functioning well. The result was a congenial and hilarious meal, interspersed with songs and pranks.

Following the serious address of the evening, made by Herbert Chase, associate editor of *American Machinist* and *Product Engineering*, on American Passenger-Car Gearsets, the party adjourned to a neighboring room where a large Christmas tree awaited. Here "Casey" Jones, who was reputed to have made a "hole in one" during the last golfing season, was made the object of a trifold presentation. First he was handed a miniature golf stick. Another member then, with due ceremony, presented him with a dummy ball. Finally, Jack Stewart, not to be outdone, presented Mr. Jones with a hole. This was done by producing a doughnut, eating it and telling the golfer the hole was his.

To the tune of Santa Claus Is Here Again, Father Christmas appeared on the scene and began handing out gifts to one and all. There was considerable guessing as to who the jolly old man was, but this was set at rest when he got all tangled up in his beard and mustache and they came off, disclosing the features of the one and only "Mac., of Mack Trucks."

Rear-End Engines Coming

Mr. Chase, before starting his address, complimented the Section on its large turn-out, which he said was larger than gatherings he had addressed in Boston, Philadelphia and Syracuse, where he had presented his paper previously, as already reported in THE JOURNAL.

Answering questions, Mr. Chase said that the car of the future is likely to have the engine in the rear and that it will not be long before experimental cars with this arrangement will be on the roads in Canada and the United States. Noise, odor and heat will be carried away in the rear with this type of construction and wind resistance will also be lessened. Streamlining will be facilitated and there will be more room for passengers, even with a shorter wheelbase. Mr. Chase said he had recently seen a model of such a car, made to scale on a Ford chassis, and that the interior of the body provided room for seven persons. These cars will not be produced immediately, he thinks, but they are definitely in the picture and are being seriously considered.

Mr. Chase also expects to see a type of construction in which the wheels are individually sprung. Canadian engineers have been doing much important work along this line and this improvement is likely to be put through in the near future. Considerable quiet work is also being done on the two-cycle engine. Free-wheeling is an accomplished fact in America now, and the indications are that it may sweep the industry, as balloon tires and four-wheel brakes have done.

An announcement was made that C. F. Kettering had consented to address the March meeting of the Section, and the meeting decided to invite to the gathering members of the American Society of Chemical Engineers, the Association of Professional Engineers of Ontario, the American Institute of Electrical Engineers and the American Society of Mechanical Engineers.

Chairman A. S. McArthur presided ably over the meeting, which was voted one of the best yet held in point of numbers and good cheer.

Engineers and Behaviorism

Why Men Act That Way and Ability To Deal with Them Discussed at Cleveland

ENGINEERS as human beings were discussed by leaders in the fields of psychology and education who brought out a crowd of nearly 150 at the Dec. 15 meeting of the Cleveland Section. Dr. Yale S. Nathanson, of the Department of Psychology of the University of Pennsylvania, gave an address entitled, Mental Gears of Engineers. Pres. W. E. Wickenden, of the Case School of Applied Science, explained the differences between the 1930 and the 1830 or 1880 model of engineers. B. H. Blair acted as sponsor and presided over the discussion. Leading educators who were present as guests of the Section included the Rev. S. M. Driscoll, of John Carroll University; Prof. O. Ohmann, of Cleveland College; and Professors F. H. Vose and R. H. Danforth, of the Case School.

The meeting was enlivened by a guessing contest, won by E. F. Brunner, conducted with the aid of a Nela Park photoelectric cell that automatically counted the number of people passing it; by a demonstration of the Theremin and by the showing of motion-picture films taken at outings or meetings of the Cleveland and other Sections and of the Society in 1930. Chairman Dale S. Cole announced that the next meeting of the Cleveland Section will be held Feb. 9 and will be devoted to automotive Diesel engines, with a paper by H. D. Hill, of the Hill Diesel Engine Co., of Lansing, Mich.

Old and New Engineer Models

The 1830 model of engineer, if he had been interested at all in his limitations and latent possibilities, President Wickenden said, would have resorted to the skull-thumbing science of phrenology. In the present more skeptical age this is regarded as bunkum. Still, the engineer of today is much concerned with human leadership and the mastery of men. To accomplish this, he must be able to convince, persuade, and on occasion command. He must not only reckon with stresses and elastic limits and microstructures and indices of hardness, but with men's motives and reactions. When cold logic will not suffice, the engineer must be able to put his ideas across by force of personality. The ability to deal with human beings, President Wickenden indicated, repre-

sents the main difference between the engineer of 1930 and his predecessor of 50 or 100 years ago.

After referring to the fact that most people want subjects added to the curriculum of engineering schools, without suggesting courses that might be omitted, President Wickenden said that the student engineer might well be required to pass three special tests before leaving college. The first, swimming, would be an index of his bodily efficiency and coordination; the second, dancing, an index of his social graces; and the third, speaking, an index of his ability to put his ideas across among non-technical men. At Case School, he said, swimming and speaking are already required, and dancing is being actually considered.

Indexes to Basic Competencies

Professor Nathanson's talk sparkled with lively anecdotes and with pertinent and impertinent illustrations drawn from history and from his ex-

PROF. YALE S. NATHANSON
of the Department of Psychology, University of Pennsylvania, Who Addressed the Members of the Cleveland Section

periences in teaching and applying psychology. The discussion following ranged from modern methods of controlling young children, a subject apparently of concern to a number of members, to industry problems such as the effect of health on motivation, the evaluation of executive traits, and the examination of applicants for licenses to drive automobiles.

The speaker outlined the development of experimental psychology, particularly as regards animals, and then went on to pay his disrespect to a certain school of character analysts. These are mere psuedo-scientists, he intimated; there is a trace of truth in their work, but mostly it caters to that personal vanity to which engineers, ministers and physicians are particularly liable. Beware of evaluating traits of human beings by mere visual inspection, Professor Nathanson urged. The only sound practice is to test these traits by performance.

Probably 20 per cent of graduate engineers are totally unworthy of their education, he claimed, and would be much happier and more useful to society if trained to become good machinists or in other vocations; in fact, the State laws requiring common-school education up to the age of 16 years often have harmful effects on children who ought to start learning a vocation at an earlier age.

The basic competencies which we all have to a greater or less degree are motivation, control, intelligence, efficiency, intellect and discrimination. The first two are social, the second two economic, and the last two, educational in their nature. The last two, moreover, are acquired by formal instruction and are variable, while the others are gifts from birth and not subject to change as we grow older. But we can so order our lives as to make useful the best of these traits, whether social, economic or educational. In the wise application of these and other principles of psychology, Professor Nathanson asserted in concluding his address, lies the future well-being of the race.

Two Topics at Seattle Meeting

Airways Work of Weather Bureau and Dynamic Balancing of Engines Explained

SPOT weather reporting at hourly and half-hourly intervals for the benefit of aviators is a recent development in the work of the United States Weather Bureau, which maintains 460 observation stations on the continental airways of the Country. What the Government Weather Bureau is doing to make day and night flying safer was told at the Dec. 5 meeting of the Northwest Section at the New Washington Hotel in Seattle by M. B. Summers, meteorologist in charge of the Weather Bureau station in Seattle.

Members and guests in attendance also heard H. O. Hanawalt, of the Engineering Specialty Co., of Seattle, explain static and dynamic engine-unbalance and special balance-testing machines built by his company.

Chairman Don Gilmore presided and Al Jones, recently elected Vice-Chairman, outlined the program of coming meetings of the Section. Several committee reports were made, and the Chairman announced that weekly luncheon meetings of the committees, which other members were invited to attend, will be held at the Gowan Hotel. The Jan. 9 meeting is to be devoted to the subject of Brakes, on which a paper will be presented by John M. Wright. Subsequent meetings will deal with aviation, Diesel engines, flame, and service.

Weather Reports Complete and Timely

Speaking of the development of weather stations and reports for the special benefit of aviation, Mr. Summers said that the Federal Government has appropriated $1,400.000 per annum for this service, started in 1926.

A basic feature is timeliness in the reports, the main object being to obtain as accurate forecasts as possible for 4 hr. ahead and also for longer periods up to 24 hr. These short-period forecasts or so-called "spot" weather reports are very important, said Mr. Summers.

When the airways work started, there were 210 weather stations in the United States, at which observations were made twice daily or oftener. These are still in operation, with an increased number of daily observations being made, while 250 intermediate stations have been added, primarily for furnishing aviation reports. Some make hourly observations and reports, and some even every 30 min. Fifty stations operate continuously day and night. They are located along commercial air routes and each has from four to seven men on the staff. Observations include: (*a*) general weather condition, (*b*) height of ceiling, (*c*) visibility, (*d*) wind direction and velocity, (*e*) temperature, and (*f*) barometer readings.

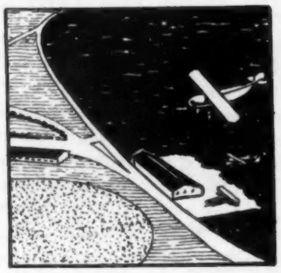
To ascertain the ceiling when it is low, miniature balloons are used. These weigh 40 grams and are inflated with hydrogen. They climb at a rate of 6 ft. per sec., so the time required for them to enter the clouds is simply multiplied by 6, which gives the elevation of the clouds in feet. At night the use of ceiling lights is necessary, the height being computed with one searchlight shooting vertically and the other at an angle. Lamps of 250-watt power are used.

For higher clouds, pilot balloons are used for computing the ceiling and wind direction and velocity. These are attached to small hydrogen-filled balloons that ascend at a rate of 600 ft. per min. For night observations, a small candle is placed in the pilot or lantern portion.

The various observations are transmitted quickly and completely to central stations and are then sent out for the information of pilots.

Engine Balance Important to Speed

Mr. Hanawalt, in his address, told of lack of engine balance that causes vibration and enumerated some of the reasons for mechanical unbalance. He emphasized the importance in aviation of correct balance of rotating members, saying that more power is produced by an internal-combustion engine when the engine is well balanced, and that recent performances of speed boats in setting up new records are due to better balance.



Both dynamic and static unbalance were discussed and the stresses and vibrations caused by each were explained. A rule set down is that the centrifugal force of unbalance increases as the square of the speed. Thus, a very slight weight of unbalance mounts greatly as the revolutions per minute increase. Machines made by Mr. Hanawalt's company test the balance of crankshafts, flywheels and large industrial-machinery parts at low rates of speed, usually around 250 r.p.m., and provide information that enables accurate corrections to be made. All are covered by patents.

"A perfect balanced machine," asserted Mr. Hanawalt, "is a source of pleasure and satisfaction to the owner, as it avoids various internal strains and assures smoother running and the maximum of power."

Following the reading of the paper, some pictures of the testing machines and the work of testing a number of automotive and industrial-engine parts were pictured on the screen. Many questions were asked and discussed.

Frame Production in Pictures

New England Section Sees Automobile Frames Built at 10,000-a-Day Rate

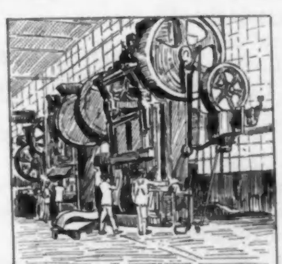
AUTOMATIC production carried to the *n*th degree, portrayed in a three-reel motion-picture film, proved as absorbingly interesting to more than 100 members and guests of the New England Section, at their meeting at the Hotel Kenmore on Dec. 10, as many dramatic pictures. The film showed the progressive production of automobile frames at the rate of 10,000 per day in the Milwaukee plant of the A. O. Smith Corp., an illustrated description of which, written by Sales Manager John J. Kelley, was published in the S.A.E. JOURNAL for May, 1928, p. 565.

The technical meeting followed a dinner in the hotel, which was attended by 32 members and a number of guests from New York City and South Bend, Ind. Chairman Albert Lodge presided at the technical session and, before the pictures were shown, read a letter from Mr. Kelley, of the Smith Corporation, giving an outline of the development of the frame-making enterprise and explaining the present automatic process. Following this part of the program, Frank E. H. Johnson, Past Chairman of the Section, gave an excellent explanation of the oil-temperature regulation in the engines of Buick cars. When he had finished, many questions were asked regarding frame production and oil-temperature control. These were answered by the speakers and by some of the Section members who are familiar with the subjects.

Romance of Practical Accomplishments

In his letter to Mr. Johnson, Mr. Kelley expressed appreciation of the opportunity of presenting the films and the story of the automatic frame plant at a meeting of the New England Section with the hope that they would arouse enough interest to induce some of the members to visit the plant and see it in operation. "No industry," he stated, "has ever given the public a larger volume in service than has the automobile industry, and no association has ever given a larger return to its affiliated industry in organized and coordinated service than has the Society of Automotive Engineers."

During the period of the last generation the automobile industry has contributed many romantic and at the same time practical accomplishments to this new era of industry, continued Mr. Kelley. The automatic frame plant has been described as a combination of both by a host of engineers who are representative of the best engineering talent from every country of the globe. Mr. Kelley recalled the creation in 1903 of the first pressed-steel frame of American make by Arthur O. Smith for the Peerless Motor Car Co. This was followed by increases in daily production to 10, 25 and 50 frames, divided among cars of the early days, including Pope-Toledo, Packard, Cadillac, Elmore and Locomobile. Then came the initial production of 10,000 frames and pressed-steel rear-axle housings for the early Ford, stepping up production to 200 frames a day. Sometimes it is difficult for him to visualize the comparison, wrote Mr. Kelley, between this early production and that of the present automatic plant with its daily capacity of 10,000 frames, or even with the company's semi-automatic plant with its daily capacity of about 4000 frames.



Some idea of the magnitude of the engineering problem that was worked out in the five years preceding the building of the present plant in 1919 and 1920 is conveyed by the statement that units had to be provided to synchronize the 552 operations required on the usual frame at a speed of 450 frames per hour, approximating 5,500,000 operations in a daily production of 10,000 frames. The nine unit-departments in which different operations are performed were shown in the motion-pictures and explained briefly in the letter.

Automatic Oil-Temperature Control

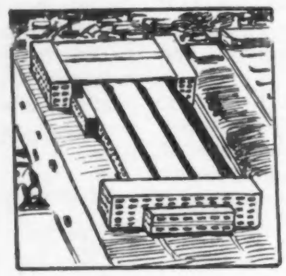
A series of lantern slides were shown by Mr. Johnson to enable his hearers to follow clearly his explanation of the Buick system of oil-temperature regulation. To be commercially successful, he said, the system had to be simple and trouble-proof. The oil-temperature regulator designed by the Buick engineers is a simple by-pass valve that adds only one extra moving part to the engine. It acts to prevent a rise of temperature that would lessen the bearing cooling value of the oil and also acts automatically to raise the temperature of the oil when the engine is started cold. The speaker explained with the aid of the slides how uniform temperature results from this circulation of the oil from the pump to the oil-temperature regulator, to the bearings and thence to a radiator shell. The regulator consists of a radiating core through the passages of which the oil is circulated and which is water-jacketed, being bolted to the cylinder block and connected to the water-pump by a hose. All water from the pump is forced through this shell and comes in contact with the surfaces of the radiating core.

On starting cold, the high viscosity of the oil builds up a resistance in the core passages of the regulator sufficient to open and allow the oil to pass directly to the bearings. With the water-radiator shutters closed, the water heats up quickly and the heat is transmitted to the oil in the regulator. To shorten this warming-up period, the pressure-relief valve discharges oil back into the oil-pump body instead of into the sump. When the oil temperature is raised sufficiently to reduce the resistance to flow in the core passages to less than that to hold the by-pass valve open, this valve closes

and all the oil supplied by the pump passes through the core of the regulator, where it is further warmed by the circulating water passing through the core. The regulator maintains the oil at a safe temperature under all conditions of driving, according to Mr. Johnson.

January Meeting on Wheel Alignment

At the next meeting of the New England Section, to be held on Jan. 13, Will Dammann, president of the Bear Mfg. Co., of Rock Island, Ill., is to give a paper on Axle and Wheel Alignment and Their Effect on Tire Wear and Shimmy.



The speaker will explain the importance of correct alignment to secure easy steering and avoidance of excessive tire wear and discuss the dependence of correct alignment on accuracy of adjustment of pitch, toe-in, axle-caster, turning radius and tracking. The effect of poor wheel alignment in producing wheel wabble will be demonstrated. Many new developments in engineering practice have resulted from recent studies of wheel alignment, and special problems have been introduced by front-wheel drives. Mr. Dammann will explain the new types of equipment developed for accurate servicing of automobiles in regard to axle and wheel alignment and the need of a continuous campaign to educate service mechanics to perform the necessary operations to realign the axles and wheels as accurately as the operation is performed at the factory.

Coach Operation Studied by Oregon Section

ONE of the Oregon Section's most interesting meetings of the year was held at the Multnomah Hotel in Portland on Dec. 12, with nearly 50 members and guests present at the dinner. The program that followed was arranged by the Motorcoach Committee under the chairmanship of Carroll C. Humber.

G. A. Schreiber, of the Hall-Scott Motor Car Co., said that interchangeable units such as cylinder-heads with valves in the head, cylinder-blocks and even complete powerplants decrease the cost of motorcoach maintenance by reducing the stand-by time of the complete vehicle while some engine-service operation is being performed. Some operators are making a practice of stocking extra cylinder-heads, with a set of valves already ground in, so that, instead of stopping the whole transportation unit for a valve regrind, the only time lost is that required to remove the head and valve assembly and replace it with a new one.

Cylinder-blocks sent to the factory in lots of ten or more are ground by production methods at a considerable saving over the customary charge in a regrinding shop. Meantime, if extra cylinder and piston assemblies are carried in stock, the loss of operating time for the vehicle is reduced to the minimum.

Two factors that have contributed largely to the success of modern motorcoach transportation are good roads and balloon tires, said M. R. McNeill, of the Firestone Tire & Rubber Co. A long line of development in many stages accounts for the progress from the first pneumatic tire, invented about 1845 and made of canvas and rubber with a tread of leather, to the modern motorcoach balloon tire capable, in the largest size, of carrying a sustained load of 9000 lb., while traveling at 60 m.p.h. Not only has this been accomplished, but more ton-miles of payload are rendered at a lower cost today than at any previous time. This saving can be appreciated, said Mr. McNeill, when it is remembered that approximately 95,000 motorcoaches are now in daily operation in this Country.

Braking Capacity Important

Heavier vehicles, faster schedules and more attention to safety factors make the design of brakes very important, in the opinion of the next speaker, R. E. Culter, of Ferodo & Asbestos, Inc. In many designs of the past, braking capacity was sacrificed for some other design factor. "Insufficient brake area does not permit of either satisfactory stops or a satisfactory lining mileage," said Mr. Culter, "and the defect cannot be overcome by service. If a low-friction lining is used to obtain mileage, stopping ability is sacrificed; if a high-friction lining is used to assure capacity for quick stopping, then good mileage cannot be obtained."

Fundamentals of Body Design

The long wheelbase and wide tread of motorcoaches subject the body to severe stresses. To keep body maintenance at the minimum, the body and chassis should be designed in correlation. This is best accomplished if both are designed and built in the same plant, according to Edward Dagner, branch manager for the Fageol Motor Co. Some manufacturers favor a cast-aluminum cowl in one unit, with both the cowl and the body flexibly mounted to the frame.

No motorcoach design can be considered successful unless it satisfies three fundamentals, said R. A. Guthridge, representing The White Co. in Portland. Its production should be profitable to the manufacturer, its operation profitable to the transportation company, and the transportation it offers appealing to the public. Continued demands for faster intercity service may soon call for two distinct types, in Mr. Guthridge's opinion, one for intercity and the other for city service.

Carroll C. Humber, of the Longview Public Service, said that the systematic accumulating of valuable operation data in permanent and detailed records affords a foundation for intelligent economical motorcoach operation. From such data can be evolved systematic inspection and maintenance schedules that would be impossible without usable records of past performance. These records, to be usable to the best advantage, should be compiled to show performance for the month, for the year to date, and if possible for the life of the equipment.

Begin Sparking, End Gassing

Southern Californians Told about Magnetos and Ignition Distribution, and Debate Engine Troubles

MEMBERS of the Southern California Section to the number of 75 received a full course in the theory and practice of modern "sparking" at its meeting at the Los Angeles City Club the evening of Nov. 21.

Sparks, their necessity to the functioning of the gasoline engine, their cause and how to control, improve and regulate them were explained in detail by E. E. Tattersfield, of the Electric & Carburetor Engineering Co.; Harry Stewart, of the E. A. Featherstone Co.; and J. F. Dixon, of the J. F. Dixon Co. The three speakers proved, very definitely, that "sparking" is more than an evening's diversion in the parked car.

The guest at the meeting was A. J. Underwood, director of Section and Aeronautic Activities of the Society, who congratulated the Section on its activities of the last year and complimented the members on the growth of the Section.

The meeting was a lively one, with Chairman Patton, Past-Chairman Fairbanks and Mr.

Underwood contributing many amusing remarks, some irrelevant, some quite pertinent. Many of the members evidently were "from Missouri" and by their questions kept the speakers on the alert to prove their points and satisfy the desire for knowledge concerning magnetos and ignition systems.

Magneto Development Reviewed

Mr. Tattersfield sketched the history and development of the Robert Bosch Magneto Co. up to the present day, and, after giving an exposition of the principles of the magneto, described in detail the new *F* unit now manufactured. Exceptional performance at high and low speeds was claimed for this unit. Members who have had trouble with magneto lubrication gave an impromptu cheer when Mr. Tattersfield stated that the new unit needs no lubrication in service.

Both Mr. Tattersfield and Mr. Stewart described the new one-piece magneto frames now in use, showing that these frames eliminate many parts from the magneto itself.

Mr. Stewart, in his paper on the American Bosch, delved deeper into history than did Mr. Tattersfield, recalling the experiments of Humphrey Davies and Michael Faraday. He then described the work of Robert Bosch, of Germany, and Frederick Sims, of England, in the development of the magneto that was the forerunner of the present high-tension mechanism.

Evolution of Modern Distributors

Many of the important problems of ignition manufacturers were explained by Mr. Dixon, who used lantern slides to illustrate his talk. He described the evolution of the Mallory system, showing the construction of many types of distributor and recounting the troubles of developing circuit breakers suitable for modern engines. Automatic spark-timing governors were then discussed, the speaker pointing out that the automatic governor is needed on the modern high-compression engine, as manual control is virtually impossible.

M. C. Merrill, of the Defiance Spark Plug Co., spoke briefly concerning the contribution made by his company to ignition apparatus.

An airplane argument was settled by L. F. Merrill, of the Axelson Aircraft Engine Co., who stated that aircraft engines use and need the rotary-magnet type of magneto.

In answer to a question raised by E. Favary, Mr. Tattersfield described the laminated pole-shoes used in the new Bosch magneto as being constructed of soft iron, insulated with shellac.

"Swedish iron?" inquired Mr. Favary.

"No, Polish iron," interjected Mr. Underwood.

A plea for the use of a non-corrosive metal in the manufacture of screws used in magnetos was made by H. C. Detmers, of the Cudahy Packing Co., who declared that the screws in his magnetos corrode at the point of contact with the wire. Mr. Pyle, of the Robert Bosch factory, stated that the fault had been noticed and had been remedied by the use of a new metal that is better than the alloy formerly employed. He suggested the use of oil to prevent that corrosion on the magnetos now in use.

At this point Bob Reinhardt, of Western Dairies, began to speak, but talk of cows was voted down, and instead, W. J. Richards, automotive electrician of Western Dairies, was permitted to report that interrupter wear was his chief problem. Mr. Tattersfield stated that in the new *F* unit the problem has been solved by the use of better materials.

"Gassing" of motorcoaches suddenly broke into the discussion, with Mr. Patton describing his experiments on the coaches of the Los Angeles Motor Coach Line, in which an intake vacuum release was used to prevent pumping of gas at low speed.

Mr. Ramsey, of the Standard Oil Co. of California, informed the members of experiments that showed conclusively that an engine does not pump oil at low speeds, popular opinion to the contrary notwithstanding.

Colonel Fairbanks then took the floor to delineate the problems of a newly organized committee that is planning a revision of the State law regarding truck brakes. He asked the members to examine and test the brakes of their trucks, as more accidents are caused by faulty brakes than are usually attributed to them. He told of tests conducted on the highways, which proved that few trucks have adequate brakes and that none can meet the law as it now stands.

The meeeting, which began with sparking and changed to gassing, remained that way until the close. Mr. Underwood showed motion pictures of the National Air Races of last August and of the Metropolitan Section outing to West Point.

Chairman F. C. Patton was elected to represent the Section on the Nominating and Sections Committees of the Society.

Met. Section Aircraft-Radio Show

Members See Newest Apparatus Displayed and Demonstrated and Hear Operation Described

WHAT MIGHT BE called Metropolitan Section's Aircraft-Radio Show was held on Wednesday, Dec. 10, at the A.W.A. Clubhouse, New York City, when thousands of dollars' worth of the newest aviation radio apparatus was displayed at the monthly Section meeting. The show was staged by Charles Froesch, of the Fokker Aircraft Corp. and the Metropolitan Section's Vice-Chairman for Aeronautics, in connection with talks given by Paul Goldsborough, vice-president of Aeronautical Radio, Inc.; Charles I. Stanton, airways engineer of the Department of Commerce; and H. N. Willets, of the Western Electric Co. Mr. Froesch presided and introduced the speakers.

How Weather Reports Are Broadcast

An understanding of flight communications calls, first, for an intelligent understanding of the air-systems map, said Mr. Goldsborough, who went on to explain the various routes over which daily passenger and mail flights are scheduled. He pointed to the example of the railroads as a key to a logical extension of air-transport lines but gave credit to the marine services for having blazed the trail for the application of radio to commercial aviation. Today, ships of the air send as well as receive messages, just as do ships at sea.

Mr. Goldsborough told about the Government weather service, with 40 Q-KW radio-phone broadcast stations in operation, and explained the radio range-beacons. "Only those of us," he said, "who have seen flight operation changed from the mere dispatching of an aircraft blind to some distant point, sometimes called barnstorming, can realize the tremendous help that these radio aids are to the safe and efficient handling of aircraft."

In addition to the Government stations, said the speaker, 84 radio-phone stations are located at advantageous points along the airways and are privately operated by the aviation companies. These have a power output of

400 watts and their carrier wave is 100 per cent voice-modulated. They operate in the 5000-kc. band during daylight hours and in the 3000-kc. band during the dark hours. The aircraft operating in conjunction with these ground stations use a set with 50-watt output 100 per cent voice-modulated. The total additional weight of the aircraft is 100 lb. Consistent 100-mile range is possible.

Complete details of the Department of Commerce airways services were furnished by Mr. Stanton, who explained the ground telegraph system for the collection of weather data and the radio system for its distribution to pilots, with special emphasis on operating methods. The hourly weather-reporting sequences used on New York airways were cited as examples.

"For instance," said Mr. Stanton, "Boston starts sending over the circuit at 50 min. after the hour; then follow in order, so rapidly that it seems as though one individual were operating the keyboard, Stafford Springs, Hartford, Bethany, Armonk, Mitchel Field, Newark and Hadley Field. Every report appears on a tape at every keyboard in the circuit. Assume that the 9.50 a. m. sequence, Boston to New York City, is just completed. The radio operator at Hadley Field, N. J., shuts down his radio beacon promptly at 10 o'clock, gives his station announcement, then reads off the local weather reports in sequence. This broadcast takes about 3 min. and is followed immediately by turning on the radio beacon. At 10.05 the Boston radio-station operator does exactly the same thing, so that any pilots in the air between New York City and Boston have been able to get the information from whichever station is nearest to them, usually the station on whose radio-beacon course they are flying."

According to Mr. Stanton, the ground system now has 5650 miles of wire, with an outlook for 8500 miles next year and 13,000 miles in 1932.

The importance of radio beacons oriented to coincide with the airway course was stressed. The signals can be heard at any point within the transmission radius of a radio beacon, but the characteristic guiding signal can be picked up on only four definite straight-line courses. An explanation of loop transmission, characteristic signals and marker beacons was given.

Fog landing aids were discussed, with mention of the Bureau of Standards system, which Mr. Stanton said has been highly praised by many pilots who have tried following down the curved beacon-path until the field-edge marker beacon is passed, then pulling back the stick for a perfect landing *in bright sunshine* but who have little desire to make a trial in actual fog. Collision prevention and airways mapping were among other points touched upon.

An oral and pictorial description of aircraft radio apparatus was given by Mr. Willets, who maintained a running comment as pictures of his company's equipment were shown on the screen. "Aircraft radio," he said, "presents every difficulty met in all other radio fields. Restrictions as to space and weight are always present, yet high efficiency is essential to obtain maximum radiation with an abbreviated aerial." The speaker told how coils weighing 4 lb. have been replaced with 3-oz. coils through the use of permalloy. He pointed to the compact design of the quartz-crystal 50-watt transmitter, including four 50-watt and two 5-watt tubes but weighing only 30 lb.

Aircraft receiving sets, continued Mr. Willets, are mounted on shock-absorbers and are arranged for easy removal of the set on every trip because, for transport airplanes, radio servicing is regarded as just as vital as engine inspection. A dynamotor operated from the plane's 12-volt storage battery supplies 200-volt plate current for the receiving tubes and 1050-volt plate current for the transmitter tubes. Ground-station equipment was also pictured and explained.

Motion pictures of air-flow around various types of airfoils were shown next and included remarkable motion studies of flight conditions with monoplane, biplane and triplane types with and without flaps and slots.

The display of equipment included a complete 200-watt R.C.A. ground-station transmitter with type AP896 modulator unit and General Electric transformer. An R.C.A. short-wave receiver type A.R. 1496-D for 12 to 80-meter wave-lengths was demonstrated, together with the Western Electric 8-A aircraft transmitter and 9-B receiver.

A cutaway Wright engine driven by an electric motor and carrying Breeze radio ignition shielding was in operation. Other exhibits included the Hamilton radio-shielding manifold of the Aero Corp. of California and Eclipse aviation generators.

The discussion which followed the meeting included a statement on the wave-length situation by former Radio Commissioner Caldwell, who referred to the possibility of using modulated light-beams to talk over. Clayton C. Shangram, of American Airways, Inc., urged that airplane manufacturers give more consideration to radio installation and shielding requirements, pointing out that operators are now required to do a great deal of work that could be done better at the factory.

Among those present were Q. A. Brackett, of the Westinghouse Electric & Mfg. Co., Chicopee Falls, Mass.; H. Breitmeyer, Jr., of the Fokker Aircraft Corp., Teterboro, N. J.; C. S. Anderson, of the Bell Telephone Laboratories, New York City; E. A. Demonet, of the Western Union Telegraph Co., New York City; R. L. Meredith, of the Aircraft Radio Corp., Boonton, N. J.; and F. E. Gray, of the Eastern Air Transport, Atlanta, Ga.

For January, the Metropolitan Section is preparing to entertain members of the Society from all over the world at its Annual Automobile Show Dinner at the Hotel Commodore, on Jan. 5. Harry L. Horning, president and general manager of the Waukesha Motor Co., will be one of the speakers on, What 1931 Will Bring to Motordom.

Wind Resistance Holds Hoosiers

Large Gathering Sees Wind-Tunnel Motion Pictures and Hears about Research To Overcome Drag

THREE PHASES of wind-resistance study and the effects of wind resistance on vehicle performance were presented to 235 Indiana Section members and their friends on Thursday evening, Dec. 11, at the Severin Hotel, Indianapolis, by three speakers, who approached the subject from different angles. Their addresses were copiously illustrated with slides and six reels of motion-picture film. Prof. H. M. Jacklin, of the School of Mechanical Engineering at Purdue University, presented a research paper on Determining and Predicting Vehicle Performance, in which he reviewed the data that had been developed by various authorities, disclosed the laborious work done on the subject by research men and told of the steps leading up to the present study that is being carried on at Purdue and other research points.

In leading up to the subject of wind resistance, Professor Jacklin showed the other factors that dissipate and use up the power of the automobile engine even before wind resistance gets a chance to absorb the greater part of the power at top speed. The power losses due to the engine itself; the car weight, size and shape; the wheels and tires; the gear reduction in axle and

transmission; and to the accessories can be determined more or less closely by means of a large variety of laboratory equipment. As examples, slides were shown of some of the testing equipment in the Purdue laboratories.

The external factors of road and wind resistance have been studied by many investigators and a large accumulation of data exists from which can be predetermined the amount of power consumed by normal automobile bodies. The Purdue methods of measuring wind and road resistance and other external factors were shown, together with slides of the formulas developed and the methods of applying these in predicting not only the amount of power available at the wheels but what will be left, if any, for acceleration and hill climbing at various speeds. Much of the apparatus shown has been developed especially by Purdue for such research work.

Tunnel Tests Increase Racing-Car Speed

The second paper, which had particular reference to wind resistance of automobile racing cars, was presented by Homer H. Jacobs, in charge of the wind-tunnel laboratory of the United States Air Corps at Wright Field. Mr. Jacobs presented a large number of slides and motion pictures that graphically portrayed just what wind resistance does to cars, airplanes and other objects. His presentation began with the showing of the wind tunnels at Wright Field and the measuring instruments employed in the work. He also showed a series of racing cars that have achieved world records, together with pictures of these cars in the wind tunnels and the steps in their development as a result of the wind-tunnel studies. Among the pictures were some of Major Segrave's car, in which he made the 203-m.p.h. straightaway record, and of Captain Campbell's car with and without the fairing in front of and behind the wheels, which fairing saved 80 hp. at 250 m.p.h.

Mr. Jacobs told how a 1/10-scale wind-tunnel test of Major Segrave's car was made in England, and said that the real trouble was in having the center of pressure somewhere around midway of the car. Changes in design because of this enabled the designers, by sacrificing speed, to incorporate much greater directional balance and to move the center of pressure backward by adding weight and reinforcement and enlarging the body. They also imposed a negative lift upon the axles to give the car additional traction, so that, in case the car was thrown clear of the ground, the rear end would come down first and perhaps prevent capsizing.

Mr. Jacobs also told how, with a wind-tunnel model of Frank Lockhart's old track racing car, it was possible to make "a calipered car, as one might say," upon which to base calculations for the final car that at one time in the tests established a speed of 225 m.p.h. By fairing the sides, front and tail of the old car, the wind resistance of the old design was cut down and the known speed of this general design greatly increased. The final car was designed and constructed on the findings of the wind-tunnel tests of models of the old and the new car. Aerodynamically the body of this completed Lockhart car, which was involved in a fatal accident resulting from a burst rear tire, was far in advance of others but the car had less directional stability than some racing cars, notably Segrave's, which was absolutely stable, the vectors being a few inches in the rear of the center of gravity. Thus the wind tunnel, said Mr. Jacobs, can build for safety as well as for speed and the minimum of wind resistance consistent with safety.

Studies in Airstream Deflection

Two reels of motion-picture film were run off showing wind-tunnel tests of airstream deflection by various objects placed in different positions in the airstream. Smoke-screen chemicals painted on the leading edge of the objects gave off smoke that enabled the stream lines to be photographed, giving a very clear conception of the formation of eddy currents and other forms of air-flow that were consistent and remained constant as long as the object was held in the same position in the tunnel. Changing the contour and the angle of attack produced different formations of air-flow. These studies provide a certain means for determining ways of reducing wind resistance and drag.

Wind-tunnel experiments made at the Imperial University at Tokio, Japan, were also presented in motion pictures. In these experiments smoke was injected into the tunnel ahead of the objects to be photographed in fine streams through a series of very small orifices. Deflection of these approximately parallel streams revealed the action of the airstream in its course around the object.

One of the reels depicted the gas flow through valves of several types, and when the exhaust valve was shown in action several hard-working engineers were heard to ejaculate, "Now we know why the dog-gone things burn up so fast at times." The chances are that this Tokio motion picture will assist in the redesigning of valves, valve guides and valve seats. "You never can tell just when one of these meetings will give you food for thought, even if the subject is seemingly far afield from your own work," said one serious-minded member who gets a great deal of fun as well as work out of life.

May Design Cars to Cheat Wind

Chairman Louis Schwitzer, president of the Schwitzer-Cummins Co., next presented a paper dealing with wind-resistance research at the University of Charlottenburg, Germany, that carried into practical terms the papers of Professor Jacklin and Mr. Jacobs. He showed in actual practice the streamlining of speed cars and the exact losses resulting from internal friction and road and wind resistance, as broken down by the exhaustive series of tests conducted at Charlottenburg and elsewhere in Europe. One car shown in slides, with graphic charts of its actual performance, expended 51.6 per cent of its engine power in fighting the wind at 84 m.p.h. Wind resistance absorbed 48 per cent of the effective power of a smaller open car at 75 m.p.h. Considering these facts, the speaker said:

> The average sedan as built today would waste nearly 80 per cent of its power in battling the wind at 70 m.p.h. Since we cannot afford to increase the horsepower and other factors much further to force our vehicles through the air, in the face of the demand for still higher road speeds, we may be forced to build our cars to cheat the wind, even if it necessitates designs that we might judge queer by our present standards. We may have to mount the engine in the rear and employ independently sprung wheels to keep each driving wheel in close contact with the earth at all times, as does the Tatra car made in Jugo-Slavia, three motion-picture reels of which we show to end the meeting.

Antics of Six-Wheeler Create Hilarity

The three speakers held the unusually large crowd of nearly 250 members and guests straight through to the end of the meeting. The motion pictures of the Tatra car can be guaranteed to hold any Section audience that may be gathered for some time to come. There's a laugh in nearly every foot and a staggering amount of information in what a 6-hp. car can do with six independently sprung wheels, the rear four of which are drive wheels. It is a tank without the mass and weight of a tank, and with apparent room for six or more persons. It went over plowed ground and mountains and through seemingly impenetrable swamps like nobody's business and brought the big meeting to a close with everyone grinning and crying for more, even though the Section broke one of its hard and fast rules by extending the session about one-half hour beyond the 10 p. m. closing time, that has been observed ever since the Section was formed.

No meeting of the Indiana Section is to be held in January, but D. G. Roos will give a Review of the Shows paper

(*Continued on p.* 110)

Chronicle and Comment

The Big Event A GLANCE at the announcement of the Annual Meeting program brings out the fact that the various committees in charge of this big meeting have provided a delectable diet for the many interests that the Society represents. Opening on Monday morning, Jan. 19, with a Standards Session, the five days in Detroit will be crammed to overflowing with technical papers and discussions of almost everything automotive, from torsional vibration to the safety aspects of car construction.

During the Annual Meeting new committees will meet and programs will be established for another year of active advancement in the various fields of endeavor in which Society members are interested.

Details of the Annual Meeting program will be found on pages 1 and 3 of this issue of THE JOURNAL and in the accompanying Supplement.

For Marine Enthusiasts MANY considerations involved in fitting the boat to the engine and the engine to the boat will be brought out by the prominent engineers who are to appear at the Motorboat Meeting of the Society at The Home Making Center, in the Grand Central Palace, New York City, on the morning of Thursday, Jan. 22. This meeting is a cooperative affair under the auspices of the National Society together with its Metropolitan Section and the National Association of Engine and Boat Manufacturers.

Read the details on page 4 in this issue of THE JOURNAL.

To Assist the Quartermaster FROM the office of Gen. J. L. DeWitt, Quartermaster General, has come the request that the Society organize a committee to cooperate in an advisory capacity with the Quartermaster Corps of the Army with regard to its motorized equipment. In purpose, this body, to be known as the Military Motor Transport Advisory Committee, will be identical with that of the Ordnance Advisory Committee, which has functioned very successfully for a number of years as a consultant to the Ordnance Department.

President Warner has appointed A. W. Herrington to serve as Chairman of the Military Motor Transport Advisory Committee, and this appointment was ratified by the Council at its Detroit meeting on Dec. 9.

Discarding the Crank APPARENTLY one group of engineers have sufficient confidence in their product to eliminate the crank as a secondary means for starting, and incidentally as an item to rattle in the tool-box. This fact and many others are disclosed in Austin M. Wolf's informative review of Automobile Engineering Progress that begins on p. 19 of this issue. In studying Mr. Wolf's report of the new automobile offerings, we find that radiator caps and associated parts are becoming vestigial; at least they are in some cases relegated to a place beneath the hood, where they will be sufficiently convenient for infrequent access.

We find new entries in the realms of the small car and the large car as well, with appropriate improvements in performance and reliability. Obviously, commendable advancement has been made in the field of comfort and ease of control. Intake and exhaust silencers have worked wonders in eliminating objectionable vibration and noise. The adaptations of more suitable gear types properly installed have brought greater quietness and better performance to transmissions and rear ends. Shock-absorbing shackles, improvements in steering linkages and other refinements have added to the ease of manipulation.

Perhaps the outstanding advancements are to be found in the transmission. Easier shifting is certainly characteristic of the newer types of mechanism that are found amidships. Free-wheeling is a subject of very keen interest and discussion.

Mr. Wolf's article is well worth careful reading, for it not only describes new features of body, chassis and accessory design, but also points out numerous very interesting developments in the production of various elements.

Back to White Sulphur in June SOCIETY MEMBERS will be particularly pleased to learn that the Meetings Committee has, after a very careful analysis, recommended to the Council, and that the Council has approved the recommendation, that the next Semi-Annual or Summer Meeting be staged at White Sulphur Springs, W. Va., from June 16 to 19.

Modern additions have brought to the Greenbrier Hotel unexcelled facilities for the accommodation of a record-breaking attendance, and it is certain that this year's Summer Meeting will establish a new standard for this regular event in the Society's calendar.

By-Laws Amended IN ACCORDANCE with Council action, the By-Laws of the Society have been amended to cover the appointment of an Assistant General Manager.

As reported in detail in the August issue of the S.A.E. JOURNAL, the Council appointed C. B. Veal to fill this position.

The amendment reads as follows:

> The Secretary and General Manager, after his appointment at the first Council meeting after the Annual Meeting of the Society, shall, with the approval of the Council, appoint an Assistant General Manager of the Society.

Upson a Member of the Board THE PRESIDENTIAL appointment of R. H. Upson as a member of the Board of Award for the Wright Brothers Medal was approved at the Dec. 9 Council meeting.

It will be recalled that the Wright Brothers Medal is awarded each year to the author of the best paper presented before the Society on an aeronautical subject. The award for the year 1930 will be decided by the following members of the Board: E. P. Warner, E. S. Land and R. H. Upson. Mr. Upson's term will expire with the award of the 1932 Medal.

Automobile Engineering Progress Disclosed at Shows

By Austin M. Wolf[1]

THE LAST YEAR has seen the introduction of two automobile extremes, the diminutive European-type car and the luxurious American cars with engines having more than eight cylinders. The Baby Austin, with its four-cylinder 2.2 x 3-in. engine of 45.6-cu. in. piston displacement, created considerable interest, and we now see the introduction of the Mathis as the second vehicle of this type. Following the lead of the Cadillac, with its 16 and 12-cylinder engines, the Marmon company is introducing a 16-cylinder car with an all-aluminum engine.

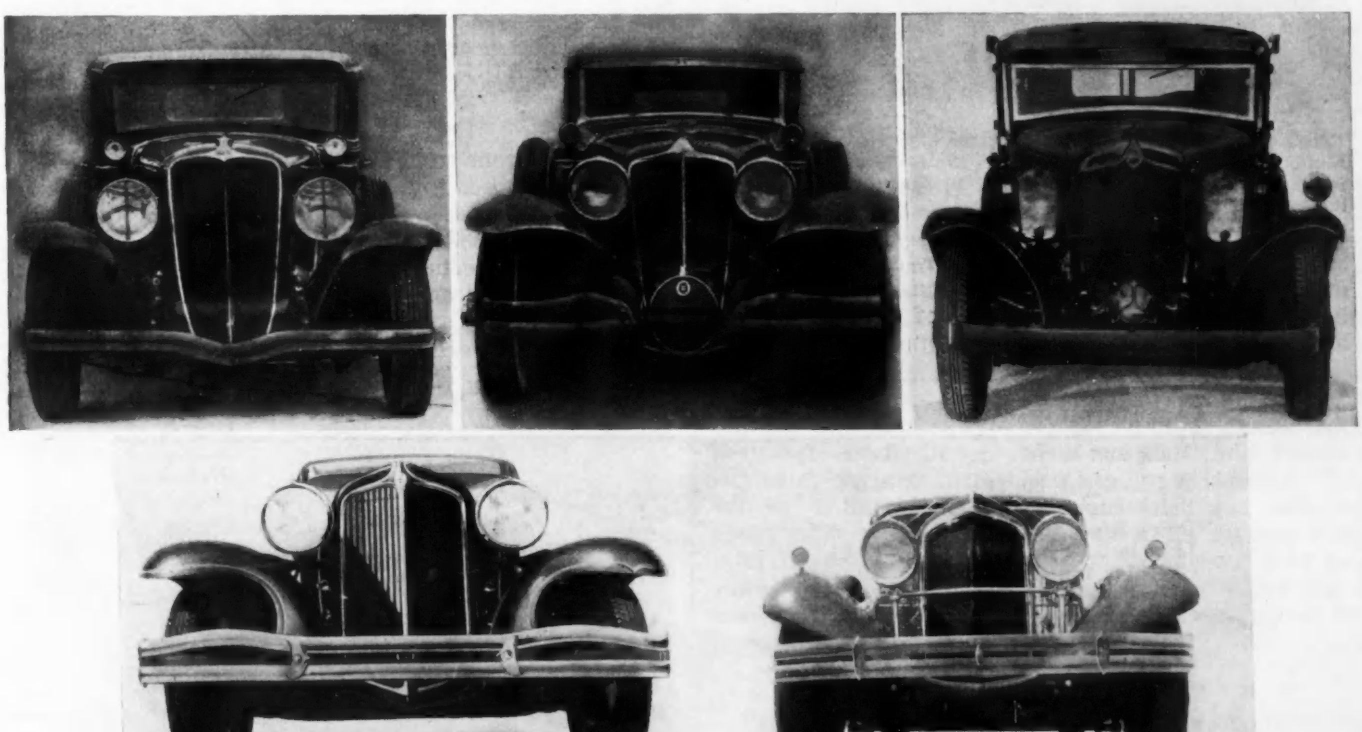
The adoption of free-wheeling is the other outstanding development, and there can be no question that it furnishes a distinct link in the evolution of the transmission of the future. Certainly the ease of shifting has set a new standard in the way of control.

The chief virtue in using a large number of cylinders is the steadier torque-output that results in decreasing the stress variation without increasing the stress of all the members in the transmission line from the engine to the rear tires. While present 16 and 12-cylinder engines in production are all of the V type, experiments are being made with other constructions. It will be recalled that one of the Indianapolis racing cars that gave a creditable performance utilized two vertical eight-cylinder banks geared together at the rear end.

[1] M.S.A.E.—Consulting automotive engineer, New York City.

POWERPLANTS

The Cadillac and Marmon 16-cylinder engines have a 45-deg. angle between the axes of the two banks, which gives equal firing spacing. Whereas a 60-deg. angle is required on a 12-cylinder engine for equal firing, the Cadillac has a 45-deg. angle. The unequal spacing is claimed by some to diminish torsional vibration of the crankshaft by reason of the breaking up of the otherwise perfect synchronism. The Lincoln engineers have always maintained this view in their use

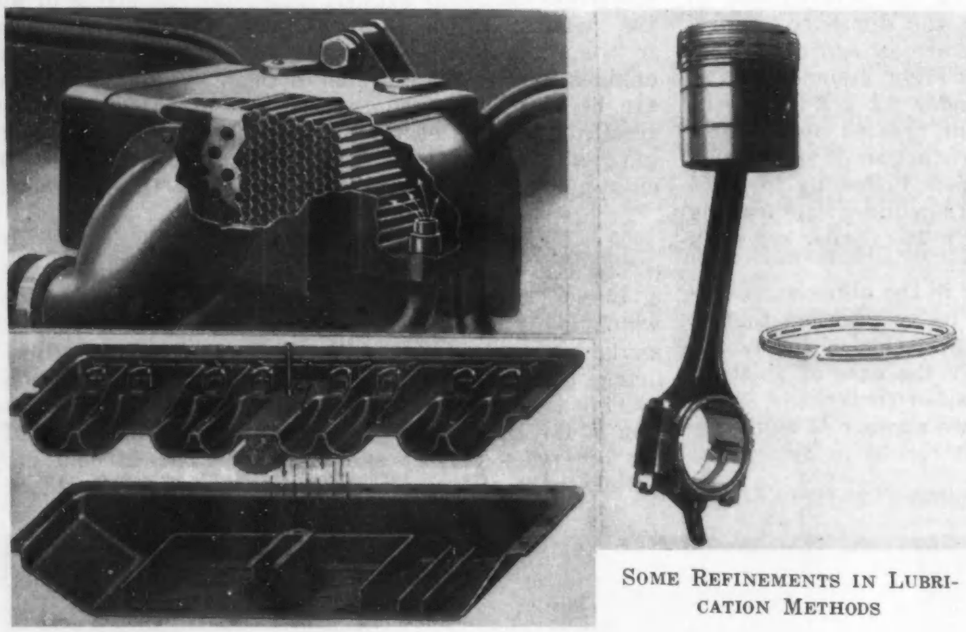


COMING CARS SHOW DEEP, NARROW RADIATORS, LOW TOPS AND WIDE-FLARING FRONT FENDERS

Auburn — Chrysler — Cord — Reo — Checker Cab

of the 60-deg. angle for their eight-cylinder engine. It is interesting to note that the Lycoming company has produced a 12-cylinder marine engine in which a 70-deg. angle is used. The new Marmon 16 has $3\frac{1}{8}$ x 4-in. cylinders, giving a displacement of 490.8 cu. in., and develops 200 hp. at 3400 r.p.m. The crankshaft has five main bearings. There are 2.45 cu. in. of displacement per horsepower; 1 hp. for each 4.65 lb. of engine weight, and 1 hp. for each 20 lb. of car weight.

The demand for increase of power is keeping up, as is disclosed by increasing bores and also the perfection of details, resulting in greater engine efficiency. The new engines are more quiet in operation, thereby increasing driving comfort. Some of the quieting measures, which will be described later, consist in the use of the intake silencer, redesigned fans, slow cam-ramps, helical oil-pump gears, insulating of the exhaust pipes and the provision of noise insulation on the dash.



SOME REFINEMENTS IN LUBRICATION METHODS

(Top) Oil-Temperature Regulator on the 1931 Buick Eight. (Bottom) Oil-Cooling Pan on the Hudson and the Essex. (Right) T-Slot Piston and Oil-Control Ring in the Hudson and the Essex

SOME RANDOM COMPRESSION RATIOS

Make and Model	Ratio
Buick Eight, 80, 90	4.5
Buick Eight, 60	4.63
Buick Eight, 50	4.8
Lincoln	4.95
Chrysler Imperial	5.0
Special Head	6.0
Chrysler Eight	5.2
Special Head	6.2
Austin	5.1
Hupp Eight	5.2
Franklin	5.31
Cadillac	5.35
La Salle	5.35
Willys Eight	5.4
Cadillac 16 and 12	5.5
Marmon	6.0

Compression ratios have been kept at a conservative value to assure maximum smoothness of operation. A few random compression-ratios are given below.

The Marmon 16 has an aluminum-alloy unit cylinder-block and upper half of the crankcase. Case-hardened steel cylinder-liners are used, held at the top by the head gasket and at the bottom by two rubber rings. To decrease the weight, every possible part of the engine is made of aluminum alloy. Packard discloses a new cylinder-block construction in that the manifolds are bolted to slanting surfaces, giving easier gas passageways from the valve throats to the manifolds.

Combustion-chamber designs that incorporate a vertical wall at the edge of the minimum clearance space over the piston[2], as a means of retarding the flame front by the scrubbing and resultant cooling action of the gases against this wall, are coming into production, as will be seen in the new Oldsmobile.

Valve Timing and Springs

Valve timing on the Franklin engine has been changed by eliminating the previous overlap, which heretofore has been regarded as essential for high-speed performance. If overlap is present, the high vacuum occurring within the cylinder at part throttle draws in exhaust gas and contaminates the incoming charge, resulting in uneven firing and poor idling[3]. Of interest also is the timing used on the Lincoln, which is decidedly different from the conventional. Buick uses the same "high-speed timing" on all models, even though the small eight has a single carbureter while the two larger engines have duplex carbureters.

Timing of the inlet and the exhaust valves on these three makes and on the Dodge engines is as follows:

VALVE TIMING ON FOUR MAKES OF ENGINE

	Inlet Valve		Exhaust Valve	
Name	Opens, Deg.	Closes, Past Bottom Dead Center, Deg.	Opens, Before Bottom Dead Center, Deg.	Closes, Deg.
Franklin	14 Past T.D.C.	51	70	12 Past T.D.C.
Lincoln	22½ Before T.D.C.	66	48½	At T.D.C.
Buick	1½ Before T.D.C.	56½	54½	30½ Past T.D.C.
Dodge 6 and 8	6 Past T.D.C.	46	42	8 Past T.D.C.

To reduce valve-spring surge, a variable-pitch spring is used on the Franklin, the coils being closer together

[2] See S.A.E. JOURNAL, October, 1930, p. 432.

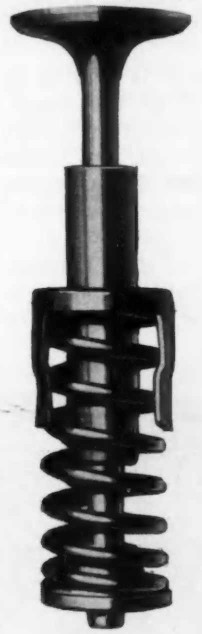
[3] See S.A.E. JOURNAL, October, 1930, p. 439.

at the ends than at the center. Double springs are used on each valve on the Franklin and the Marmon 16. The Studebaker has a valve-spring damper that fits over the top of the spring, and two depending and opposed fingers contact with the center coils. The Thompson Products Co. is producing a valve guide made of pearlitic iron alloyed with nickel and chromium which is considerably harder than the ordinary soft-iron guide. A bronze guide is employed for the exhaust valve on the Franklin, because of the high heat-dissipating properties of the metal.

Pistons, Rings and Connecting-Rods

Elliptical pistons formed by cam grinding are used by Hudson as a means of equalizing the unequal expansion that occurs with some aluminum-alloy-piston designs. This provides more clearance at points of maximum expansion and allows closer clearance without danger of seizure. The T slot of the Hudson piston is not carried down to the bottom, thus providing a stronger skirt construction. Aluminum pistons are sometimes thrown out of round by the distortion resulting from the wristpin lock-screw mounting. On the Hupmobile a lock-screw passes through the pin and threads into the top of the piston boss. The effect is to draw the upper and lower sides of the boss toward the pin. The wristpin is reinforced by increasing its wall thickness where the lock-screw passes through it.

Oil-pumping caused by increased driving speeds has presented a problem. The cocking of the piston in the cylinder tends to wear an oval face on the oil ring, destroying its effectiveness. Ring performance depends on the maintenance of face contact at the edges, which is nullified by the oval wear. The Perfect Circle Co. has brought out a ring in which the center of the face has been cut away to leave a narrow bearing width at each side, making center contact impossible and maintaining contact at the edges. A new ring chamfered at the top, with a groove in the center and a scraper step at the lower edge, has been developed by the Hudson company, which uses two such rings out of the four per piston. Cadillac is now radially drilling the two lower ring-grooves in the piston instead of only the lowest one, and also uses four rings.



STUDEBAKER VALVE-SPRING DAMPER

A Cutaway Cap Fits over the Head of the Spring and Exerts a Gentle Pressure on the Sides of the Coils, Preventing Spring Surge

The Marmon 16 has a forked and blade type of connecting-rod for opposite cylinders, which are therefore in transverse alignment. Last year Nash introduced an aluminum-alloy rod having a steel cap. This construction is maintained on the large eight but the other models have light steel rods, rifle-drilled for wristpin lubrication and with aluminum-alloy caps. Heat dissipation is accelerated thereby and considerable weight is saved. The steel upper half controls the expansion in the same way that the steel lower half does in the case of the aluminum-alloy rod.[4]

Crankcase and Shafts More Rigid

Polishing of the aluminum upper half of the crankcase has been inaugurated by Cadillac on the 12 and 16-cylinder engines. Ribbing of the crankcase parallel to the dividing-line flange is becoming standard practice. Chevrolet has stiffened its crankcase and cylinder-block unit by thickening the roof of the crankcase and applying external ribbing. A 43-per cent increase in rigidity has thereby been accomplished at the expense of a $1\frac{1}{2}$-per cent increase in weight. The Studebaker bell-housing is provided with external ribbing to give increased rigidity during machining and when in the car.

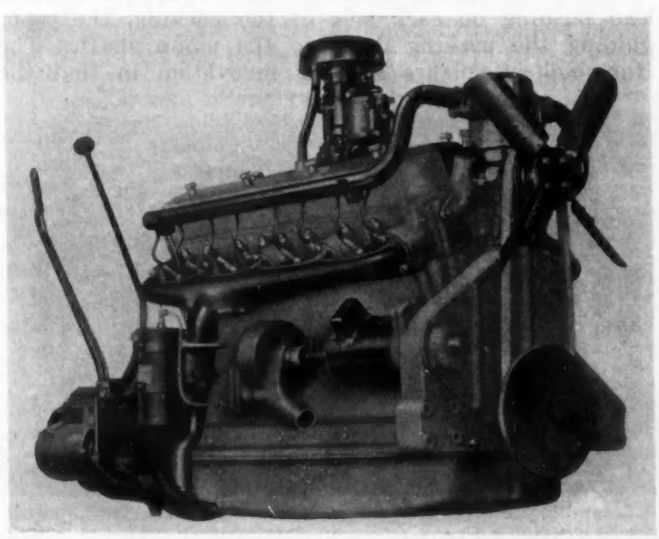
Thermostatic control of the crankcase ventilating system is continued by Cadillac. The Marmon 16 draws crankcase vapors into the carbureter, whereas the ventilating system on the Chevrolet has been changed so that the engine fumes are conducted out below the pan as a protection against corrosion.

Crankshaft rigidity is increased wherever possible to combat torsional vibration. Chevrolet has added more metal to the cheeks for this purpose. A very simple form of vibration damper consists of a rubber plate bonded to a disc attached to a crankshaft hub and to a disc riveted to the fan pulley-flywheel. This construction is used by Dodge, Hupmobile and Chrysler. Packard has combined the application of vulcanized rubber discs and spring-controlled friction elements. Buick is using a ring-type damper mounted on the cheek behind the first cylinder. Four sets of radially disposed laminated springs furnish the resilient elements. This damper is machined and is removable and balanced entirely independently of the crankshaft, making it an interchangeable unit by itself. Studebaker uses two plates between a number of steel balls which force them apart as the speed increases, thus multiplying the pressure on the friction elements.

Oil-Cooling and Oil-Pumps

Preserving the oil viscosity by means of oil-cooling is a distinct trend brought about by the sustained high speeds that are possible today. Hupp continues the practice of partitioning off 2 in. of the radiator core and forcing the oil through this by means of a separate pump. A pressure-relief valve in the line short-circuits the radiator core when the oil has high

[4] See S.A.E. JOURNAL, September, 1930, p. 314.



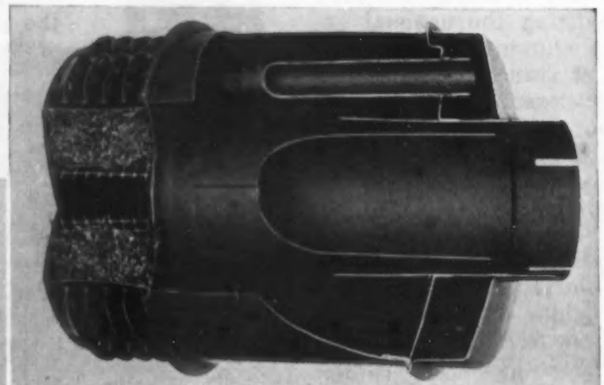
MARMON 16-CYLINDER V-TYPE 200-HP. ENGINE

viscosity, as when starting up in cold weather, thereby preventing excessive pressure being built up in the core.

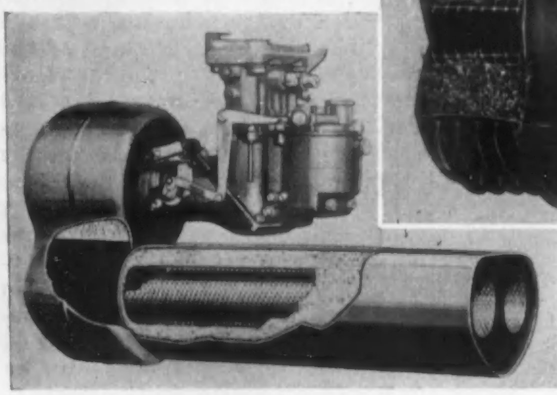
The oil-water intercooler used by Buick is located at the water inlet to the cylinder-jacket from the pump. The intercooler consists of a small enclosed radiator-core, water from the pump flowing through the tubes while oil from the oil-pump flows around them on its way to the bearings. Again a safety by-pass valve is provided.

The oil-cooling capacity of the pan of the Hudson has been increased by causing the returning oil to flow toward the ends thereof and then back to the center before it can be picked up by the pump. This is accomplished by vertical partitions.

A vane-type pump is used in the Austin, and two jets in the crankcase direct oil against the crankcase cheeks between Nos. 1 and 2 and Nos. 3 and 4 cylinders. Passages drilled from these cheeks convey the oil to the connecting-rods. The oil-pump on the new Marmon 16 is placed at the forward end of the crankcase-oil base and is driven by a roller chain from the forward end of the crankshaft. Packard, Buick and Franklin use pump gears cut with helical teeth to assure quiet action. The oil-pump capacity has been increased in a number of cases as a further means of carrying off heat from the journals and to help in the general oil-cooling process. The Franklin pump has an increased number of teeth to increase the pumping capacity. The capacity of the Buick pump has been increased about threefold.



Intake Silencer Made by A. C. Spark Plug Co.



Studebaker Carbureter-Intake Silencer

Most engines have the oil passages drilled in the cylinder-block and upper crankcase half as insurance against broken oil piping. Pressure lubrication of the valve tappets is used in the Packard and Hupmobile, both of which have tappets of the finger type. The rocker arms on the Franklin are lubricated by means of a lead from the oil-pump, which passes the oil through a special filtering element of artificial stone, thence to a check-valve which prevents draining during periods of engine idleness, and finally through a needle-valve having a very small taper that permits a fine adjustment in the rate of feed.

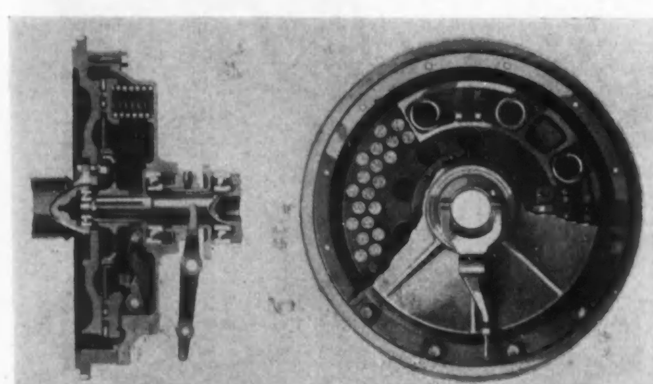
The electric fuel-gage also acts as an oil-level gage on the Chrysler Imperial, this method having been introduced two years ago by Hudson with the Moto Meter Gauge & Equipment Co.'s system.

Larger radiators are provided on a number of cars because of the increased power output of the engines. The larger cooling capacity has been secured in other cases by speeding up the water circulation. To make a more intimate and wiping contact with the air, the Lincoln has flattened radiator tubes set at an angle. An air-scoop effect is obtained by such constructions as are employed on the Chrysler and Studebaker, in which the pan extending back from the bottom of the radiator shell to the front cross-member creates an upwardly tapering passageway to the radiator core.

To promote circulation of the air around the engine, hood louvers are higher and sometimes placed toward the rear of the hood. They are also stamped in the engine pans to allow egress of the air. Fans have been raised for increased effectiveness, as will be noted in the new Hudson. Lycoming was one of the first manufacturers to introduce a combined fan and water-pump unit, the pump being unrestricted in height by the cylinder-block.

In the general search for quieter operation, changes have been made in blade shape and pitch to reduce fan noise, fan speeds have been reduced and there has also been a change-over from four to six-blade construction, which makes possible the use of a smaller diameter. The Chrysler Imperial has a shrouded fan to increase the cooling capacity. Buick, Dodge and Chrysler have mounted the thermostat on the water-outlet riser of the cylinder-head and operate the radiator shutters from this point.

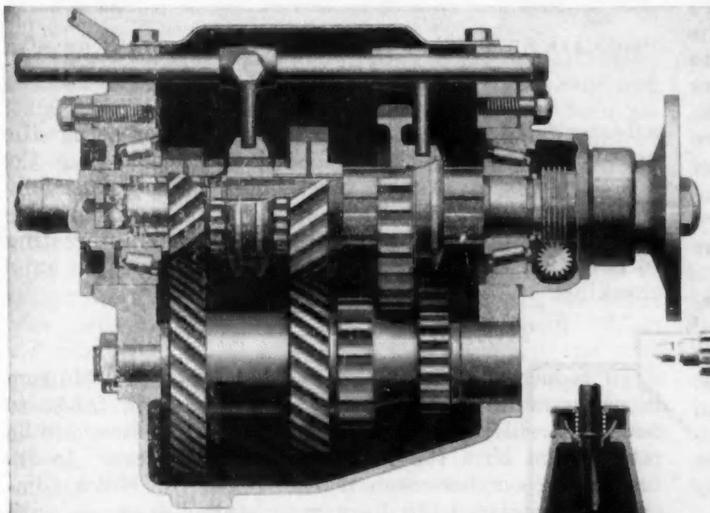
On the Marmon 16 a double-impeller water-pump is used, each impeller serving a single bank of cylinders. A new packing of plastic material that comes in stick form has been introduced by Hupp. This is inserted in a drilled and tapped hole at the top of the pump body, being forced into the space around the pump shaft by a long cap-screw retained in position by a lock-nut. An additional seal is furnished by a tapered lead bushing on each side of the packing, the taper guiding the packing down to the pump shaft. The Hupmobile furnishes another innovation in that the



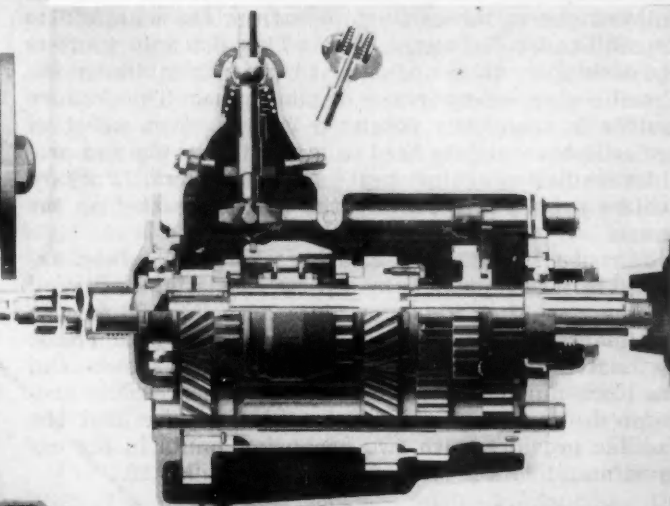
Hudson Single-Plate Clutch, Showing in Broken-Away Portion Three of the Series of Pressure Springs

water-jacket and valve-chamber covers are pressed against the unfinished block, the intervening gaskets assuring probably a better seal than with a machined surface.

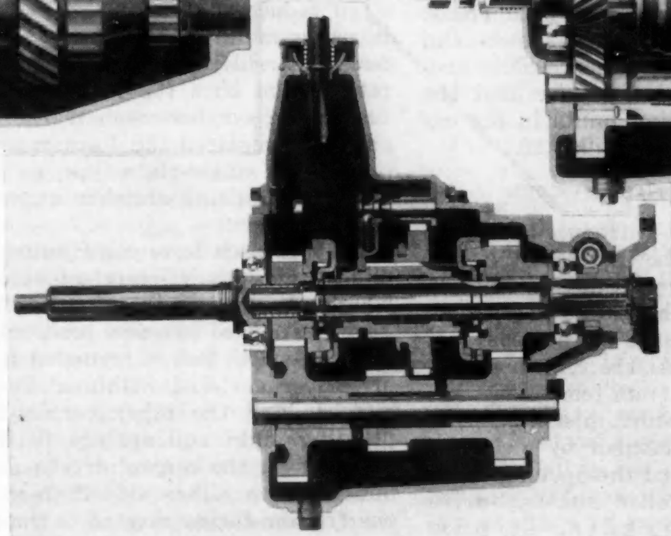
The Franklin company has redesigned its blower so that it consumes 53 per cent less power. It is slightly larger in diameter than the former model and has 32 blades instead of 55. The redesigned blade curves backward. The cross-flow of air between the Franklin cylinders is retained and a deflector is secured to the right side of the engine so that the heated air will leave at the bottom, keeping the heat from the driving compartment. A door on the outside of the deflector can be left off if heat is desired for winter driving.



NASH HELICAL-GEAR THREE-SPEED TRANSMISSION



HUPMOBILE FREE-WHEELING HELICAL-GEAR TRANSMISSION



OLDSMOBILE SYNCHRO-MESH TRANSMISSION, PROVIDED WITH SPRING-PRESSURE CONTROL

Intake Silencers and Manifolding

The downdraft carbureter is steadily increasing in popularity, one important feature being the possibility of obtaining cooler mixtures. Lincoln is a convert to this system and uses a dual carbureter. The exhaust gases are brought out directly from the valve throat instead of being detoured around the intake ports.

The outstanding achievement of the year is the development of the intake silencer, which breaks up or decreases the intensity of vibrations in the manifold. The higher frequency of pulsations with engines of eight and more cylinders has fostered this development. The principle of the resonator, as used in the units built by the A. C. Spark Plug Co., is to be found on the Graham, Nash, Dodge, Hupmobile, Chrysler, General Motors cars and others.

The Burgess exhaust muffler introduced last year by Studebaker, consisting of a perforated tube passing through the steel outer shell and having the intervening space filled with steel wool, is used in modified form by the Studebaker Corp. for an intake silencer. Balsam wool is substituted for the steel wool of the muffler, and two perforated tubes are used instead of one.

The silencer is mounted horizontally below the carbureter and bolts to the housing of an air-cleaner, forming a surge chamber at this point. These devices minimize the tendency of the vibration of the air column in the manifold to extend beyond the carbureter.

Means for Avoiding Vapor Lock

Vapor lock has been the subject of considerable research[5]. Various means are being found in the new cars to combat these situations. On the Packard the fuel line from the rear tank runs forward on the outside of the frame to protect the fuel against the heat of the exhaust pipe and muffler. On the Hupmobile the fuel line is carried from the rear tank on the side opposite the muffler and exhaust pipe to the front of the engine, transversely across the frame and back of the fuel-pump.

As the fuel-pump, when in the usual location on the side of the crankcase, is subjected to considerable heat, Packard mounts the pump at the front of the engine on the timing-gear cover in an elevated position where it is swept by the fan draft. It is driven by an eccentric on the front end of the camshaft through the intermediary of a push-rod. Other makers shroud the fuel-pump to protect it from heat. The Lincoln company is a recent convert to the fuel-pump.

Mufflers Insulated

Hudson uses an intake-manifold by-pass through which the fuel mixture passes at high velocity for low and idling speeds. This also facilitates cold-weather start-

[5] See S.A.E. JOURNAL, June, 1930, p. 736.

ing. Chevrolet has placed a rubber boot over the accelerating pump of the carbureter to protect it against moisture and thereby prevent sticking in winter.

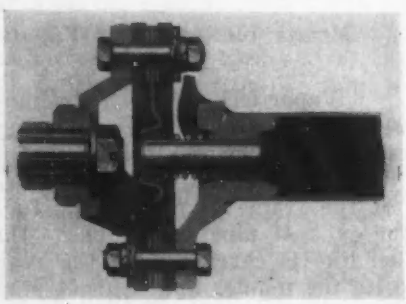
The downdraft carbureter has simplified manifold layouts and the exhaust-pipe installation. The exhaust manifold with center outlet is gaining ground. Whereas previous V engines have had their exhaust pipes brought to a single muffler, the Marmon 16 has separate mufflers and tail-pipes. A special asbestos insulation on the Auburn covers the exhaust pipe from the manifold to a point under the engine pan. This not only protects the carbureter from undue heat but tends to deaden the metallic ping set-up in the exhaust pipe. The Auburn muffler is completely insulated with a ½-in. sheet of fire asbestos which is fixed in a metal covering and provides insulation against heat as well as sound. Packard utilizes rubber in mounting the muffler bracket on the frame.

The usual exhaust-manifold gaskets have been replaced in the Hupmobile by a paste consisting of linseed oil and graphite, which provides a seal to fill up the tool marks on the block and also acts as a lubricant for relative movement between the manifold flanges and the block during expansion or contraction. This provision is necessary on a long pipe, and we find the Cadillac provided with two expansion joints in the exhaust manifold and one joint on the Cadillac 12.

Engine Mounting and Electrical Systems

The fifth point of mounting, introduced on the Cadillac 16, has been extended to the Cadillac 12 and 8, which have a trunnion at the rear of the transmission which is supported by rubber bushings. The Hupmobile has tension-type rubber mountings at the front, set at an angle to increase stability. At the rear, a solidly mounted steel cross-member runs from one frame rail to the other and surrounds the clutch housing. The bell-housing is supported on this member by means of four rubber mountings spaced around the opening.

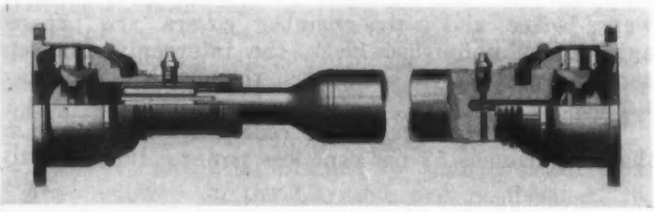
Marmon introduced the double-roller camshaft-drive chain. It now utilizes a triple roller-chain on the 16-cylinder model. Lincoln now mounts a double pulley on the forward end of the camshaft, one belt driving the fan and the other belt driving the generator. The latter is swung outwardly for belt-tension adjustment.



Oldsmobile Propeller-Shaft Centering Device

The coil on the new Hudson is removed to the top of the cylinder-block, where it is out of the way of possible spray from the radiator. The Cadillac company is continuing on its other models the coil mounting brought out with the 16, where it is recessed in the radiator top-tank.

The wiring feature of the new Auburn is the accessibility of the stamped-aluminum ignition-cable conduit, which opens up with a distributor cap, the removal of any bolts and nuts for the operation being unnecessary. To assure a cooler spark-plug-shell electrode, the Graham has a solid-copper gasket instead of the usual asbestos-filled copper gasket, thereby increasing the heat-flow from the shell. The A. C. Spark Plug Co. has developed a 14-mm. spark-plug, which is used by Nash on the twin-ignition engines. More makers are placing the starter button on the dash. It is interesting to note that the Marmon 16 has no provision for hand cranking.



Propeller-Shaft and Universal-Joints of Chrysler Eight

THE TRANSMISSION SYSTEM

To reduce the inertia of the drive member, Hudson is using a duralumin driving disc, 1/16 in. thick, to make gearshifting easier. Cork-insert construction is retained on both the Hudson and Essex cars. In its use of the synchro-mesh transmission, the Buick company has replaced the former multiple-disc clutch with one of the single-plate type, as successful operation of the synchronizing clutches depends on a low spinning tendency.

Borg & Beck have contributed a manufacturing simplification by their interchangeable 9 and 10-in. clutches, which are based on the use of a flat flywheel face. They have introduced two new resilient drives, one consisting of a six-spoke hub surrounded by a uniform thickness of rubber enclosed within a die-casting on the driven member and the other consisting of a spring drive utilizing eight coil springs fitting within rectangular openings in the central driven disc and in each of the hub discs on either side thereof. The Austin utilizes one friction-facing riveted to the flywheel and the other to the pressure plate. The use of a single heavy clutch-spring is becoming obsolete, and multiple springs spaced around the pressure plate have taken its place. Uniform pressure distribution is assured thereby. The new Lincoln clutch is provided with 12 springs. The Chevrolet company has adopted a ball-bearing for the clutch pilot instead of the previous bronze bushing.

Free-Wheeling and Other Transmissions

Free-wheeling is the liveliest topic of the day when discussing transmissions. While its use in England has extended over at least the last five years, American manufacturers were reluctant to use it in any form. Studebaker introduced it and Lincoln and Hupp followed the same general construction, in which the roller ratchet is effective for high gear and the below-high gear. Whereas Studebaker and Hupp use 12 rollers, Lincoln uses 8.

The chief virtue in the Studebaker type lies in the fact that no higher torque than that transmitted through the below-high gears is impressed upon the roller unit. Depressing a button in the shift lever allows further shifting of the sliding unit, making direct connection and cutting out the rollers. In the Auburn coaster-control unit, which is synonymous with free-wheeling, a closely coiled spring is used, being grounded on the outside and fitting closely within a

surrounding cylinder. Relative rotation in one direction tends to unwind the spring and in the opposite direction tends to coil it up to a smaller diameter. In the former case, positive gripping is assured, being equivalent to a clutch, and in the latter case disengagement occurs. The Auburn unit is mounted at the rear of the transmission, allowing free-wheeling on all forward speeds. A small lever directly in front of the driver's seat engages or disengages the device.

Along with free-wheeling we find a further extension of the synchro-mesh transmission. The Oldsmobile and Buick are now equipped with this device and both retain the characteristic bronze-on-steel cone clutches of the Cadillac transmission, but the hydraulic timing device of the latter has been eliminated and a spring-pressure control substituted. In the Oldsmobile construction, the movable-cone clutch member is provided with a triangular arrangement of three straight pins of spring steel. The shifting unit contacts with the three pins, pressing the cone clutch into engagement. With a further movement of the shifting member, the pins bow outwardly and slip over the outside of the shifting member. This action releases the cone clutch and allows positive engagement with the gear after the speeds have been synchronized.

The Olds transmission is characterized by the second-speed gears being at the rear end of the case, while the low and reverse sliding gear is in the center and is mounted on the outside of the shifting member. The Buick transmission utilizes the same general principle except that the spring-give is accomplished by means of six poppets in the shifting member engaging a circular groove on the inside of the cone-clutch sleeve. These poppets exert sufficient pressure on the groove so that the cone and sleeve are moved fore and aft with the shifting member to cause engagement. Further movement of the shifting member forces the poppets out of the groove, releasing the clutch and allowing the shifting member to pick up the gear. The Detroit Gear & Machine Co. is using a somewhat similar synchronizing means, with poppets, between high and second of its helical-gear transmission. First and reverse are detrained by the conventional sliding-gear construction.

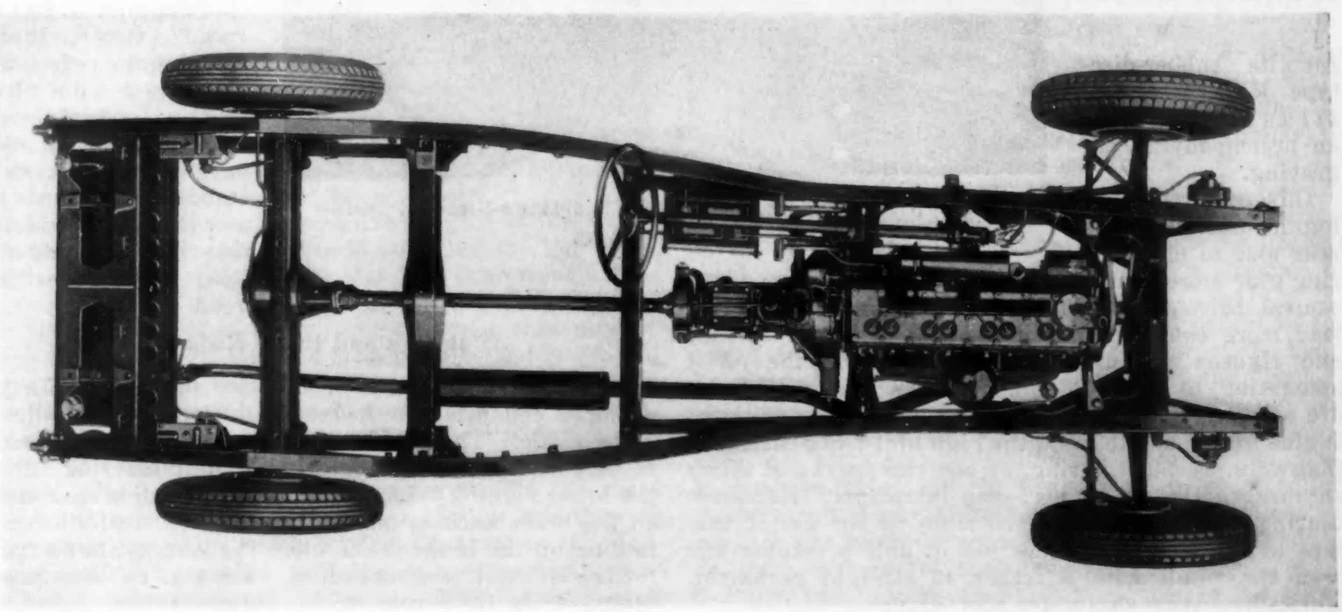
Helical Gear Teeth Gaining Ground

Helical teeth in the constant-mesh and below-high gears are becoming increasingly popular, and it is a question whether this type of transmission will replace the internal-gear construction for the below-high speed. The year marks a considerable impetus toward this type. Franklin has dropped the latter construction in favor of the helical-gear type, and Hupp and Studebaker are using helical gears. If the roller-ratchet units were removed from these transmissions we should have the same general clutching mechanism that was brought out last year and is still continued in the Reo, which utilizes herringbone gears. Nash and Marmon are also using helical gears for the second-speed and constant-mesh gearing. The Warner Gear Co. also is producing a unit of this type. Whereas Packard was using a sliding gear for third and high speeds last year, this construction has been replaced by constant-mesh spur gears.

The conventional transmission is used by Hudson, but different pitches are used on the constant-mesh and second-speed gears to reduce noise, on the theory propounded by Reo last year.

For ease of servicing Chevrolet provides a transmission case that is removable without disturbing the clutch housing. The material going into the lower-price cars is of increasingly high quality, as will be noted by Chevrolet's use of nickel-molybdenum carbonized steel for the countershaft gears. The Cadillac and the Reo Royal Eight have had their transmission ratios speeded up. Reo has a 1.38:1 ratio in second and 2.29:1 in low. With a 4.07:1 rear-axle ratio, 60 m.p.h. is possible in second and 30 m.p.h. in low. On the other hand, we find the low-gear transmission-ratio of the Hudson reduced for faster getaway.

The relative use of three and four-speed transmissions is the same as last year. The differences occurring this year are of type and not in the number of speeds. The ordinary type of gear lubricant is now giving way

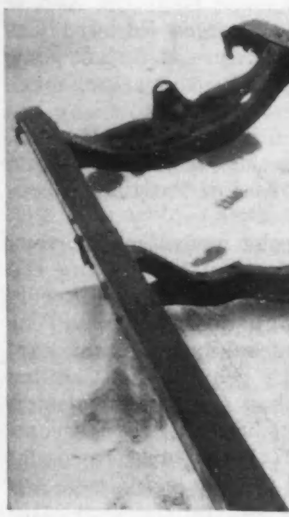


CHRYSLER-EIGHT CHASSIS, WITH WIDE FRAME FOLLOWING BODY CONTOUR AND DOUBLE CHANNEL AT FRONT END EXTENDING BACK TO CROSS-MEMBER BACK OF TRANSMISSION

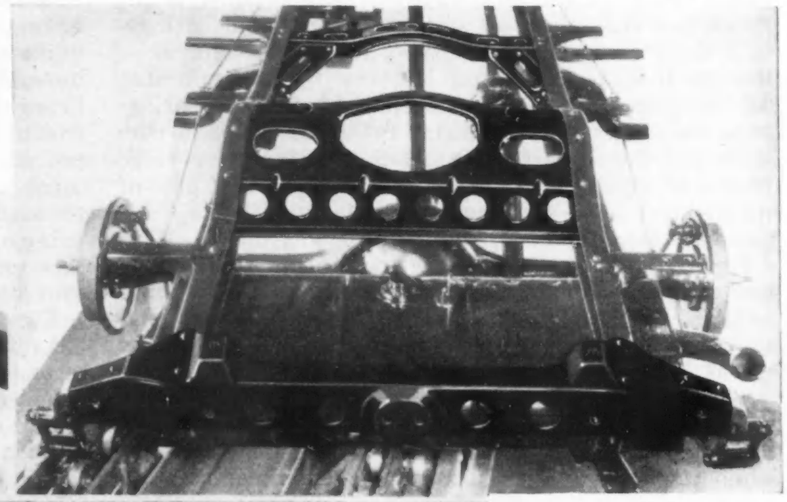
to a special type required by the use of free-wheeling and synchro-mesh devices. It is essential that a lubricant of the right viscosity be used for the correct operation of these parts.

Universal-Joints and Rear Axles

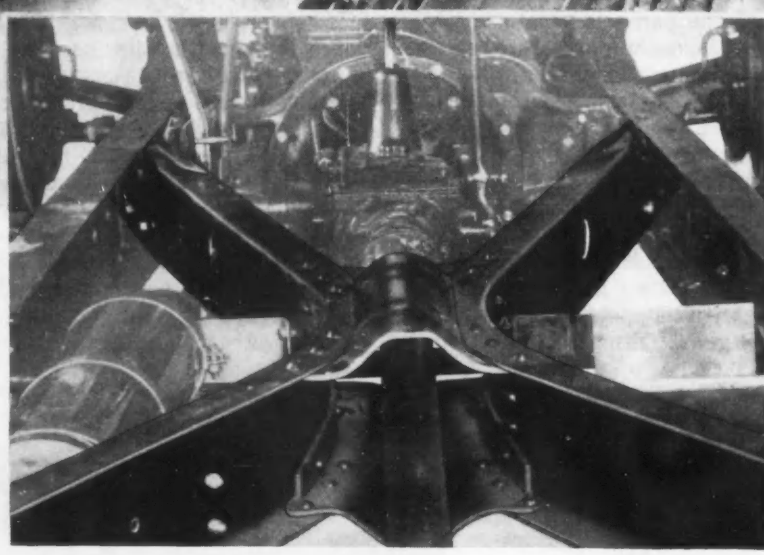
Better seal is provided in Spicer joints by the addition of a light pressed-steel ring between the yoke and the spherical cup, and this is used on the Chrysler Eight and the Hudson. The ring is centered on the yoke and is somewhat similar in action to the resilient Bakelite sealing member that the Spicer company developed in its large universal-joints for commercial use. The Oldsmobile has an interesting centering device for its rubber-disc-type joint, which is illustrated in an accompanying engraving.



FRONT END OF CHEVROLET FRAME, SHOWING FRONT CROSS-MEMBER THAT ALSO SERVES AS AN ENGINE SUPPORT



HUDSON PRESSED-STEEL CROSS-MEMBER THAT FOLLOWS CURVE OF THE FRAME KICK-UP



AUBURN X-FORM CROSS-MEMBER, WITH PROPELLER-SHAFT PASSING THROUGH THE CENTER

Offsetting the pinion mounting in the rear axle to place the ring gear more nearly central between the differential bearings divides the load more equally between the two bearings. Dodge and Hudson are using this construction, the offset amounting to about ¾ in. Pinions and ring gears are of better proportion, to take care of the additional engine torque and to avoid the high unit tooth-pressures that were prevalent during the last two years and which encouraged the use of lead-soap lubricants. Excessive bearing wear has discouraged many in the use of this type of lubricant and reduction in unit pressures has been the result with a return to straight petroleum lubricants. Axle shafts are also larger.

Studebaker is using a finer pitch in the pinions and ring gears, for increased quietness. Hupp is using a single roller-bearing instead of the former double bearing at the wheel ends, thrust being taken at the differential.

Franklin is now using a malleable-iron center housing instead of aluminum, for increased rigidity. Austin also is using a malleable-iron center, with steel-tube ends. The latter fit into hubs on the center housing and are joined by means of welds made through holes in the malleable casting. Chevrolet now runs its rear-spring clips transversly so as to avoid distortion of the housing, which was possible with the former straddling of the clip around the housing.

Lincoln and Franklin have gone to 60-in. rear tread. It is amusing to reflect at this time on the Southern special tread of 60 in. in the old days when 56 in. was standard. Auburn now claims the widest rear seat in production, màde possible by its use of a 61-in. rear-wheel tread.

Brakes and Brake-Rods

Brake-rods attached to steel cables enclosed in heavy armored conduits are increasingly popular and eliminate rattle. The cables also permit the front wheels to be turned at sharp angles without interfering with the brake rigging. Lncoln has a special guide mounted on the brake backing-plate to prevent the conduit from fouling on the brake-drum when the wheels are swung for the shortest turning radius. Olds uses cables which extend from the levers on the large-diameter tubular cross-shaft to the wheels, the only brake-rods being from the pedal and hand lever to the cross-shaft. The Oldsmobile cross-shaft is interesting because of its

universal mounting, which relieves it of all possible frame weave.

The Lincoln hand-brake now operates on all four wheels. This is the last car to relinquish the separate emergency brake. The new Marmon models divide the braking effort equally between the front and rear wheels.

Brake diameters are increasing and it is evident that, with the diameter of wheel rims decreasing, a condition will soon arise similar to that encountered in the commercial field a few years ago, when brake-drum heat affected the tires and the small rim diameters restrained braking capacity.

CHASSIS PARTS

Front-axle I-beams have been increased in stiffness. The Buick in particular has an increase of 10 per cent. Whereas most front axles have a gradually increasing round section from the spring-seat to the steering-knuckle for torsional strength, Hudson uses an I-beam with a lattice-type rib construction between the flanges.

The Logan Gear tubular front axle is a new development and is used on the Franklin and the Overland Six. The ends of the tube are formed and welded around a spool in which the steering-knuckle pin is located. The spring-seats are not welded to the axle. The tube is flattened on top and the sides taper to where they join the lower half of the tube. The seat has a wedging contact on these sides, being clamped down into place by the spring-clips.

Packard has used underslung front springs for a considerable period, and Auburn now joins the ranks. This permits a straighter axle design, reduces the torsional strain of braking and gives ample clearance for the use of a deep frame section over the front axle.

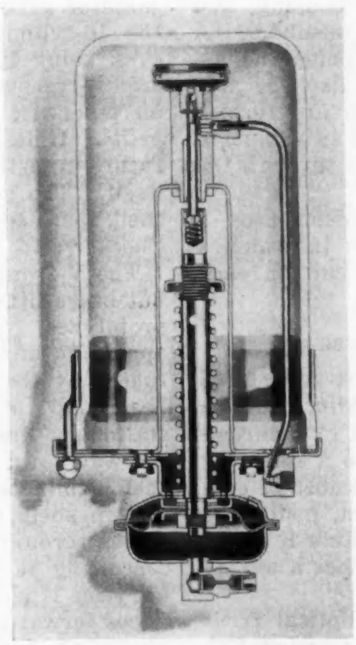
Wheels, Rims, Tires and Springs

Seventeen-inch rims are used by Reo, Chrysler and Auburn. Tires for this size are being made in 6.00, 6.50 and 7.50-in. sections. A 16-in. rim is being experimented with, and this brings up the question of how soon the rims and brake-drums will meet in conflict.

Large hubs and smaller wheels give the effect of lowness. Pierce-Arrow leads in the use of large hubs. It is interesting to note that the Ford type of welded steel spoke is now standard equipment on the Lincoln.

With the increase in rear treads, wider spreading of the rear-spring centers has been possible and is utilized for stability and the elimination of sidesway. Lincoln is leading with the longest passenger-car rear springs; namely, 62 in. Franklin is still using the full-elliptic type but has eliminated the previous welded-on spring-eyes. The top main leaf is wrapped around the rolled end of the lower main leaf, the joint being held in place by abutting clamps which support the pivot-bolts. Hudson and Essex continue with the splayed or non-parallel rear springs, to prevent sidesway. The Belflex shackle mounting used by the Checker Cab also aims toward increased stability. The fixed end of the spring is secured to a curved member, forming the lower part of a rocker-joint, while the upper, straight and slanting part is a portion of the frame bracket. Rubberized fabric lies between the two metallic joint-parts and ties them together. The shackle at the free end of the spring consists of rubberized fabric in tension, as heretofore, that slopes outwardly at the bottom at each side. The spring end is secured to the bottom of the shackle, the fixed end being above. The construction permits the use of an apron completely hiding the spring, no openings being necessary as there is no need for lubrication. Metal spring-covers are increasing in use.

The anti-kick shackle on the left side, brought out last year by Buick and Cadillac, is now used by Studebaker. As will be recalled, the cushioning springs lie horizontally. The Hupmobile uses a bell-crank and vertically mounted springs. Reo has replaced rubber shackles for the metallic type, except at the rear end of the left front spring. The rubber shackle at this point acts as a cushioning member to prevent road shock reaching the steering-wheel. The Silentbloc shackle is now being used on the various Chrysler models.



BIJUR AUTOMATIC LUBRICATING SYSTEM

This Is Operated by a Diaphragm Pump Actuated by Variation in Intake-Manifold Vacuum

Means Adopted for Frame Rigidity

Frame rigidity is essential and various means are used to accomplish this. A number of side rails have been increased in thickness or depth, and cross-member construction ties in with the side rails in a more thorough manner. The Chevrolet has an interesting rigid front cross-member which also serves as an engine support. The Hudson uses a new type of cross-member which curves with the rear kick-up of the frame and is located therein. It has cut-outs in the top section for lightness, and vertical flanges turn down at each end of the kick-up. Hudson also carries the full depth of the side rails farther back than formerly. This strengthening of the rear end of the frame materially reduces weaving at the front end.

Auburn uses an X member with a spread of 75-in. The propeller-shaft passes through the center of the X, and the general design is similar to that of the Cord frame. Due to its underslung front springs, Auburn maintains a $5\frac{1}{4}$-in. depth over the front axle, insuring a rigid front-end. The side-rail depth at the deepest point is 8 in. A channel reinforcement is inserted in the rear kick-up.

Chrysler has adopted the Dodge construction in the use of a wide frame following the contour of the body. To strengthen the bottle-neck portion at the front of the body, a double-channel is used at the front end of the frame, with the inner channel continuing straight back to a cross-member behind the transmission. This is reminiscent of the old Crane-Simplex construction. A corresponding reinforcement on the Dodge is carried back to the cross-member to which the front ends of the rear springs are anchored.

Buick has located cross-members close to the shock-absorber mounting on the side rail to avoid twisting due to the reaction from the shock-absorber. For the

same reason, Lincoln mounts the front shock-absorbers directly opposite the main front cross-member.

Wheelbases have been lengthened to give greater roominess in the bodies. We find at one extreme an increase of 2 in. for Chevrolet and at the other, 8 in. for Lincoln.

Steering-Gears and Linkage

The three-spoke steering-wheel is still gaining ground. There is also an increase in the use of the cam-and-level gear, with roller mounting of the pin. The greater over-all efficiency of this construction results in easier control. Franklin has relocated the emergency-brake lever to the center, from its former left position. Buick now mounts the gearshift-control lever over the clutch compartment, giving increased clearance in the driving compartment.

The Baker Rim Co. has introduced a new type of ball-bearing drag-link and tie-rod end. A spherical segment is contained within a spherical housing, and balls in two raceways separate the two members. A spherical button under spring pressure holds the assembly together. Two new ball-joints, also for this use, consist of two ball-cup halves which are formed with a cylindrical exterior. Each half fits in a tapered groove, and a coil spring provides take-up through the resultant wedging action.

In place of an anti-kick shackle, Hudson uses a vibration-absorbing drag-link construction in which a relatively long coil spring backs up the cup on each side of the steering-gear-arm ball.

Some Equipment Changes

The single wide-bar bumper is the vogue, being used by Studebaker, Peerless, Cadillac, Franklin, Auburn and Checker Cab. Tire covers now consist of a chromium-plated band enclosing the tire and also a side ring finished in the prevailing body color. A number of cars now have their horns mounted out in front, instead of in the under-hood location. Chevrolet mounts it below the left head-lamp, as does Ford. Hudson has a unique front mounting.

A new keynote in head-lamps is the elliptical front as used by Studebaker and Hudson. The Checker Cab lamp has a novel modified rectangular front. Fender parking-lamps are increasing, a very distinctive type having been worked out by Studebaker.

Hydraulic shock-absorbers of the two-way type are virtually standard. Watson has worked out a new cylinder-filling means, and it is noteworthy that Packard has given up its axle location of the shock-absorber unit.

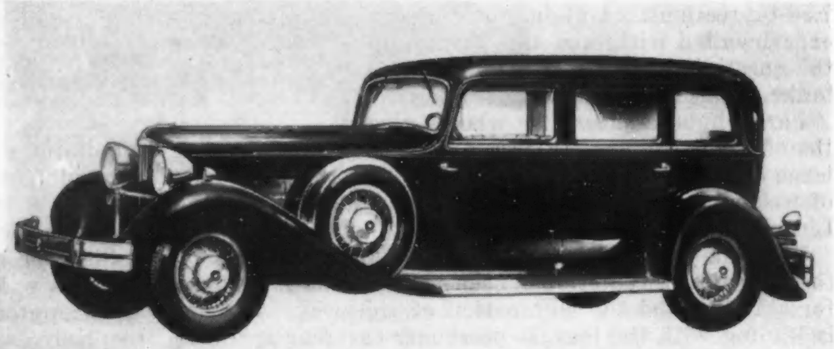
The Bijur automatic lubricating system used by Buick, Nash and Auburn is operated by a diaphragm pump which is susceptible to variations in the amount of vacuum in the intake manifold.

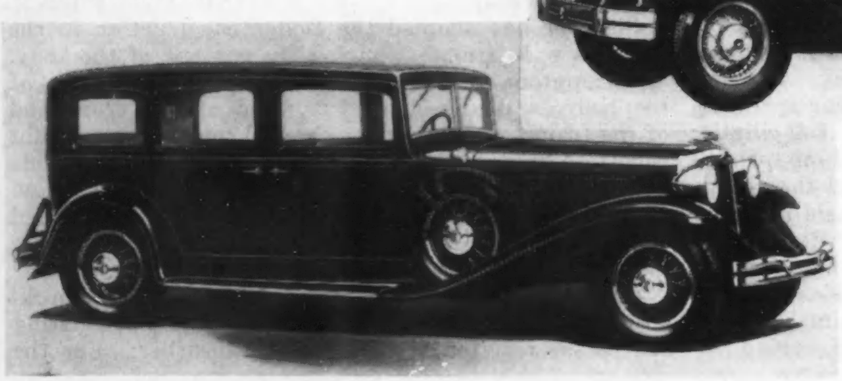
A number of instruments are of the aviation type. Auburn, for instance, uses white figures on a black background with large indicator hands, and a crowned lens-type glass over the dials. A trend exists toward the pointer-type speedometer. A feature is that it can be read accurately at a glance, in a similar manner to reading a time-piece by noting the position of the hands. It is used by Cadillac, Chrysler and Olds. There is an increasing use of package containers on each side of the instrument panel.

Radiators and Sheet Metal

Conceived as a means of preventing flying stones from injuring the radiator core in Italian racing, and commercially introduced by Isotta-Fraschini, is the radiator grille. It was first used here by Cadillac on the 16-cylinder model and is now available on most cars, being furnished by the car manufacturer or the accessory company. It is unfortunate that sometimes an otherwise beautiful shell design is hidden by the grille. Unless it should prove to be a passing fancy, future artistic effort will be expended on the grille itself. The grille is sometimes built into the radiator shell, as exemplified by the Marmon, Hudson and Checker Cab.

The V-front radiator has staged a decided comeback but bears little if any resemblance to its hard, angular prototypes. The latest designs aim toward a high-appearing and narrower effect, which is further accentuated by the absence of any horizontal lines such as head-lamp tie-rods. Studebaker has a false front of stationary fins. Chrysler uses shutters extending all the way down to the bottom of the radiator. The deep shell eliminates the former radiator apron. By using a deep shell, it is possible to carry the lamp tie-rod across through the shell and in front of the core, thus concealing it. Cord introduced this construction and Chrysler is also using it. The Chrysler V-shaped front slopes forward at the bottom. Some shells are narrowed toward the bottom, as in the new Auburn, and the same





AIRPLANE INFLUENCE REFLECTED IN STREAMLINING OF BODIES, FENDERS AND RADIATORS

The Reo Royal Eight (Right) Has a Backwardly Sloping Windshield and Curved Front Roof Panel without Visor, Long Sweeping Front Fenders and V-Shaped Radiator. The Chrysler Imperial (Left) Has a V-Form Windshield and Radiator, Sweeping Front Fenders That Give the Impression of Speed, and Eliminates Body Sills, the Frame Following the Body Contour

AUBURN REAR END (LEFT), NASH SEDAN INTERIOR (CENTER) AND REO REAR END (RIGHT)
The Rounded Rear Ends Show the Streamlining Tendency. The Reo Is Unique in Eliminating the Rear Apron and Concealing the Fuel Tank under the Sweepback at the Bottom

optical effect is produced by the Studebaker design. The ornamental circle below the radiator of the front-drive Cord has been carried out in modified form in the new Checker Cab.

Most radiator shells are chromium-plated but on several cars they are finished in lacquer to match the hood and trimmed with chromium-plated beading. The Chrysler Eight and Reo Royal Eight are finished in this manner, and in the latter the center bead extends back from the nameplate and flares off into the hood hinge.

Filler caps are becoming less and less conspicuous and, since the eye is now trained to this condition, it more readily accepts the absence of the radiator cap on the Reo, Willys-Overland and the Marmon 16. These makers feel that a cap would mar the straight-line effect of their front-end design. The filler caps are located under the hood, as originally conceived by Chalmers many years ago. Because of the prevailing high cap of that day, the filler cap was conspicuous by its absence. Buick's present radiator assembly is mounted on the frame through the shell rather than the core, which relieves it from frame weave and other strains.

Doors in the engine hood, with outside control, are rapidly replacing the louvers, a design initiated by Packard and now being used by Reo, Cadillac, Hudson, Franklin, Stutz, Peerless, Marmon and others. The Franklin hood-doors are finished in dull chromium-plate. This finish will see further use for artistic application. Louvers and hood-doors are extended higher so as to provide better egress of the air from the hood. Concealed hood-hinges are increasingly popular, and the new Marmon 16 utilizes a combination hood-handle and catch, rotation of the centrally located handle releasing the hood or locking it in place.

Inward Sweeping Front Fenders Introduced

Sweeping the fender in toward the hood presents a new style, one version of which was introduced with the front-drive car. Because of absence of the side rail extending ahead of the front axle, Cord initiated a new fender design instead of attempting to carry a dummy spring-horn, such as Ford uses, and attaching it in the conventional way. In applying this beautifully worked-out curve of the apron portion, Chrysler extends it downwardly to the inside of the front spring-horn, thereby eliminating the usual splash apron at this point. A small strip fits on the outside of the horn and hides the frame. Giving the effect of an airplane wing and symbolizing speed, Reo has introduced a front fender in which an almost straight-line sweep of the fender apron extends from the crown of the frame to the side-rail. The fender starts at the front spring-horn and sweeps back to the outside of the crown portion, with an increasing turn-under of the metal instead of a bead. The lower edge of the fender flange continues with the turn-under, resulting in a rigid construction as well as a means of softening the fender line by reason of the visually indeterminate edge. The rear fenders also incorporate this construction.

The conventional fenders have deeper flanges, giving more rigidity and better protection against splashing. Front fenders are long and sweeping, those of the new Auburn measuring 78 in. in length. In side view most fenders closely approximate airfoil section. The design at the top conforms with the motif of the radiator in many instances. Auburn uses rear fenders having an unusually long apron which extends with a graceful sweep over the gas tank and rear deck. The rear end of the frame and the gas tank are better concealed, projections or brackets being entirely absent. Any accessory that might be bolted on is applied directly against the apron, mounting means being provided immediately under it.

Chevrolet has eliminated the former horizontal pan and uses a full-depth radiator with a false bottom. The new Hudson and Marmon models have a horizontal-pan effect which, however, is below the crankshaft center.

Hudson shows a new method of fender bracing consisting of two streamline tension members which meet at the center, where a flat-type vibrator horn is mounted. Side splashes are given a distinctive touch by the use of chromium-plated kick plates or bars running the length of the splashers. Short bars are sometimes applied to the lower forward portion of the rear fenders, close to the running-board.

BODIES

Mention has been made of the airplane effect of the fenders. Our airmindedness is being reflected in the new body designs with their sleek contours and the absence of projections and gadgets. It is natural that

we should be influenced by airplane developments and subconsciously introduce characteristic earmarks from that field to our own. Furthermore, car speeds have now reached such a pace that streamlining and the reduction of air resistance are becoming very important. Thus we find that practical utility has fostered the newest designs.

The outstanding design of the year is undoubtedly the Reo Royal Eight. The front metal roof-panel curves back with a short radius from the top of the windshield. The outside sun-visor has been eliminated, and the smooth exterior has not only shown less resistance in wind-tunnel tests but one is instinctively impressed with this fact by merely looking at the car. A molding design, started in the hood, is carried back into the body, tying the two together. The horizontal molding along the side of the hood is increased in three steps, the upper step being carried up the front body-pillar and the lower steps forming the upper body-panel at the window. The drip mold forms a continuation of the front-pillar molding and is also very effective in carrying out the streamline effect of the front end.

The Reo body is also unique in eliminating the rear apron and concealing the fuel tank itself. The lower rear panel is of double curvature, being swept backward at the bottom. Reduction of air resistance is also evident in the treatment of the rear of the body. No doubt this design will create a new vogue. In general, sharp lines and corners are absent, being replaced by large curvatures to soften the lines.

Bodies Low, with Deep Sides

Rear-drive cars are low slung, following the standard set by the front-drive cars. Auburn has a phaeton sedan that stands only 65 in. from ground to roof, and the sedan model is only 68 in. high. The Lincoln body is mounted on brackets on the outside and below the top of the frame, giving an outrigger effect as well as a low mounting.

Another trend is the use of the coach-sill effect, the sill being carried below the top of the frame in a graceful curve. Chevrolet incorporates this design and it is carried on up through and into the high-priced class.

Following a design initiated by Dodge, Chrysler eliminates the body sills through the use of a wide frame following the body contour. The floor-boards and front seats are bolted directly against the webs of the side rails. On the new Marmon 16 the door sides drop down to leave only a short dust-shield.

Reo and Nash are using a T-iron center pillar. The former hangs both doors in the sedan on this narrow pillar by a single set of double hinges, making possible the use of wider doors and saving the hanging of one set of hinges. Stutz uses a casting instead of a composite front door and cowl pillar-post on all closed jobs to increase rigidity.

The Hudson top has two diagonal tension members running from opposite corners of the roof as a means for preventing rattles and squeaks. Where these members pass over the bows they are attached thereto for maximum bracing effect. Most of the doors, body panels, floor-boards, rear-seat pan and inside of the cowl are insulated with a heavy coating of a semi-plastic compound that is sprayed on. This acts both as a sound deadener and heat insulator.

Many dash partitions are also thoroughly insulated against noise and heat. Auburn uses three layers of fireproof asbestos, wool felt and, finally, a covering of composition board. The floor mat is also heavily insulated with ½-in. wool felt. The Buick dash is lined with ¾ in. of Celotex, on top of which is a ½-in. thickness of felt. Reo uses ½-in. felt over ⅝-in. Masonite and finally a covering of cardboard.

In the Reo bodies, produced by Murray, glued joints have been almost entirely eliminated through the use of steel reinforcements imbeded in antifriction paste. Wherever there is a possibility of weaving between the body construction and the steel panels, the wood sections are shielded with felt strips impregnated with antifriction compound having permanent lubricating qualities. Sills on the Hudson bodies are extended beyond the junction of the cowl with the dash to assist in strengthening the frame.

Fixed Windshields and Large Windows

The fixed windshield is becoming popular. By this construction it can extend considerably higher, increasing visibility by the elimination of the usual wide top-header. Windshields are also being given more rake for better visibility. With the use of four cowl ventilators, two at the top and two at the sides, ample ventilation is provided and the necessity for the movable windshield is remote. Some of the higher-priced cars have windshields in two sections, forming a V. In combination with a V radiator, as in the case of the Chrysler Imperial, this gives consistency of design in these two parts.

Larger rear windows are being used to afford improved visibility. A number of coupés have crank-operated rear windows that can be opened for ventilation. Reo is supplying curtains on the rear-quarter and rear-door windows. The Auburn five-passenger two-door brougham has doors 42 in. wide, giving easy entrance to and exit from both the front and rear seats. Naturally, a very long window is used in this door, which tends to give the body a long low appearance.

Besides the use of aluminum and chromium-plated kick-plates, etched-copper plates strike a new note. Doorhandle design has acquired a new lease of life, with a general tendency toward longer handles for increased leverage. Packard and Reo are using a curved type of handle that is pleasing to the eye and affords an excellent grip. Running-boards are being given considerably more attention as to detail. The molding is usually chromium-plated and has a gracefully curved edge that harmonizes with the contour of the fenders. Rubber vulcanized to the steel board is very popular. Hupp is using a linoleum type of ribbed fabric instead of rubber. The Franklin board is covered with plain black rubber, on top of which are five lengthwise rubber strips held in place by metal molding. An unusual effect is obtained on the Reo by holding the lengthwise rubber strips in place by means of chromium-plated molding with Bakelite inserts between the strips.

The convertible body continues to increase in popularity, with improved and simplified collapsible constructions. Roadsters are giving way to convertible coupés.

Color schemes are subdued in many cars and are conservative, no doubt as a psychological reaction of the times. Black, green, brown and blue seem to be the popular colors for closed models. The brighter colors, particularly the pastel hues, are being used on open cars. Color application now depends largely on the utility of the car and is as important as line design in carrying out the designers' conceptions.

Free-Wheeling

Metropolitan and Dayton Section Paper

By Delmar G. Roos[1] and William S. James[2]

ONE-DIRECTION clutches have been applied to motor-cars to prevent the engine from being driven by the car when coasting and to facilitate gear-shifting. A number of representative designs are described in detail and in relation to their location in the transmission line.

Following this is a detailed description of the construction and operation of the free-wheel device as applied to the Studebaker transmission, in which it takes the form of a single overrunning-clutch placed between the clutch gear and the splined shaft of the transmission in such a way that it serves to clutch either direct drive or second gear in either free-wheeling or positive engagement. Twelve rollers of graduated sizes are arranged in three groups in contact with three cam surfaces in the clutch. Sizes of rollers and dimensions of the cam surfaces are given.

Tests were made for durability of the device, for savings in fuel and oil, and for any increase in demands on the brakes and generator. These are reported, with tables. The advantages of free-wheeling are detailed, and changes in design and adjustment that it entailed are described.

This paper was read by Mr. Roos at a Metropolitan Section meeting, at which letters on the subject from prominent engineers were read as discussion. Mr. James read the paper at a meeting of the Dayton Section. Among the points which were covered in the discussion were the necessity of increasing the idling speed of the engine to guard against stalling, the effect on battery charging, and questions relating to the use of the engine as a brake in emergencies and on heavy commercial vehicles and to additional wear on the brakes due to free-wheeling down grades.

OVERRUNNING CLUTCHES incorporated in the drive line of automobiles are not new. This construction, usually called a free-wheel drive, enables the engine to drive the car but prevents the engine from being driven by the momentum of the car. The merits of this construction have been discussed from time to time, but few data have been given from extended experience with free-wheel cars.

Various designs have been worked out in which a free-wheel or overrunning-clutch unit has been embodied in the rear axle, installed ahead of or behind the transmission, or incorporated as an integral part of the transmission. Fig. 1 shows a typical installation in the rear axle, as worked out by Sensaud de Lavaud for an otherwise conventional spiral-bevel-gear design. In this instance, a free-wheel clutch of the multiple-roller type replaces the differential side-gear normally used at the inner end of each axle shaft. The two overrunning clutches serve as a differential in addition to permitting free-wheeling. A friction-ring member, normally restrained from rotating with the differential case by a manually controlled plunger-type stop, acts to prevent the rollers from assuming the position of backward engagement when the car is moving in the forward direction and thus permits the car to coast or free-wheel. An independent control is provided which allows the plunger stop to be withdrawn, thus causing the roller clutches to transmit torque in both driving and coasting directions when it is desired to render the free-wheel device inoperative and utilize the engine as a brake. Free-wheeling is possible in all forward speeds with this installation.

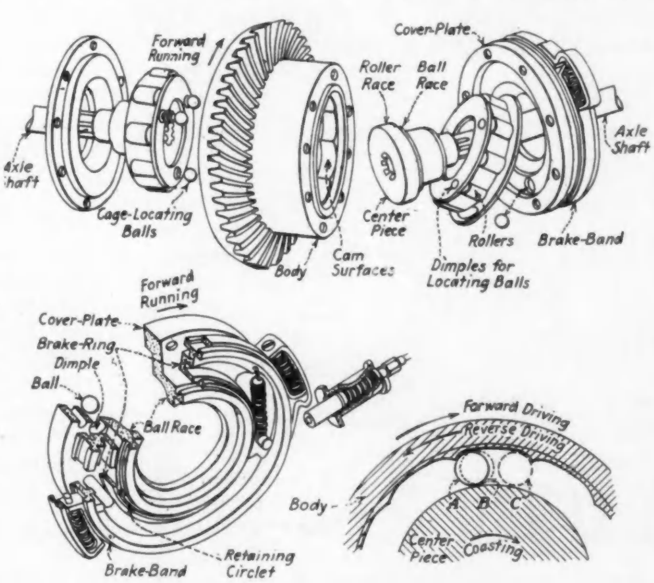


FIG. 1—DE LAVAUD FREE-WHEEL DIFFERENTIAL SUBSTITUTE

Positions of Rollers Are: *A*, Forward Driving; *B*, Reverse Driving; *C*, Coasting

Another interesting application of free-wheeling is revealed in the Weller clutch, Fig. 2. The assembly shown serves as both normal clutch and free-wheel device. In this design, driving torque is transmitted through a pair of concentric sleeves each having a mating coarse-pitch thread. The action of the screw-thread is such as to apply pressure to the clutch plates when the engine is delivering power to the transmission. When the driver releases the accelerator pedal and the engine tends to slow down,

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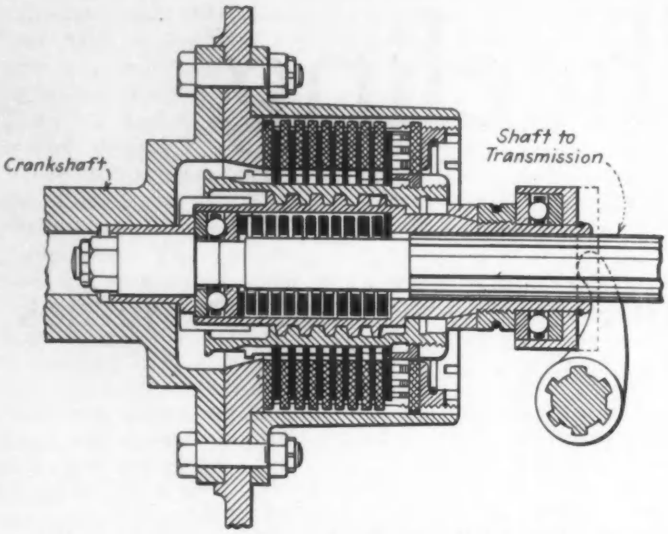


FIG. 2—WELLER CLUTCH GIVING FREE-WHEEL ACTION

A Threaded Sleeve Enables the Driving Torque To Increase the Spring Pressure. When the Transmission Tends To Overrun the Engine, the Screw-Thread Works against the Spring and Causes the Clutch To Release. When Free-Wheeling, Pressing and Releasing the Clutch Pedal Reengages the Clutch as a Positive Drive

the reversal of torque on the screw-thread causes the clutch plates to be freed, allowing the car to free-wheel until the engine is again accelerated. Another feature of this design is that depressing and releasing the clutch pedal while free-wheeling reengages the clutch, allowing the engine to be used as a brake. This design makes free-wheeling possible in all speeds, both forward and reverse.

Transmission Attachments

Several designs have been brought out in which the free-wheel mechanism has been attached to the rear of the transmission. Fig. 3 illustrates two applications of this type, in one of which the free-wheel clutch is applied as a separate unit and arranged for interconnection with the clutch pedal to increase ease in gear shifting. The other is similar except that a separate dash control is used instead of having the free-wheel unit interconnected with the clutch pedal. Fig. 4 illustrates the Vulcan free-wheel mechanism, with which a separate hand-lever is provided to render the mechanism positive.

Installations in this location permit free-wheeling in all forward speeds, but provision must be made to lock the device for reversing or for using the engine as a brake. In most cases this requirement has necessitated the use of auxiliary control mechanism.

The Farley design, shown in Fig. 5, illustrates an application of a free-wheel clutch to the countershaft constant-mesh gear of the transmission. This design provides a means for freeing the countershaft while gears are being changed. The free-wheel clutch is arranged so that it normally drives the countershaft. A linkage interconnects the device with the main-clutch pedal to release the roller-type free-wheel clutch whenever the main clutch is released, thus reducing the effective inertia of the countershaft and reducing gear clashing when shifting. In a later Farley design, the constant-mesh gears are placed at the rear of the transmission and the free-wheel clutches installed between the main-shaft constant-mesh gear and the driven shaft on which the propeller-shaft is mounted. With this arrangement, free wheeling is obtained in all forward speeds except direct drive, the principal object apparently having been the reduction of gear clashing when shifting.

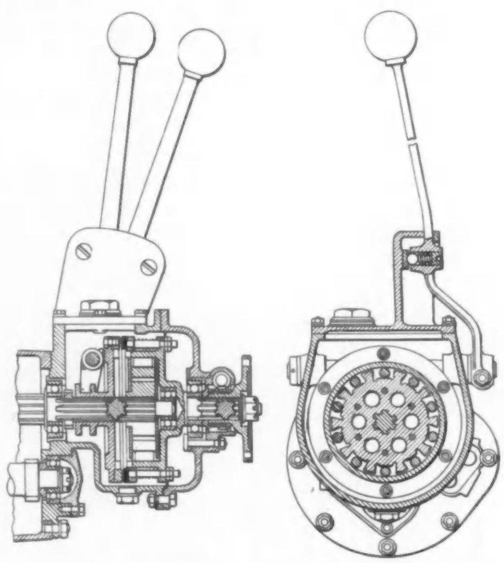


FIG. 4—VULCAN FREE-WHEEL ROLLER-CLUTCH

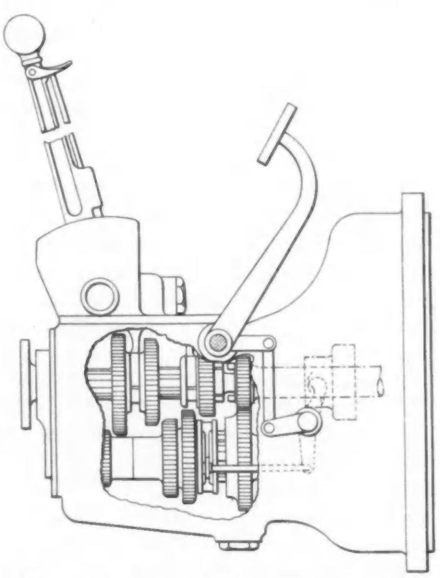


FIG. 5—FARLEY ROLLER-CLUTCH ON TRANSMISSION COUNTERSHAFT

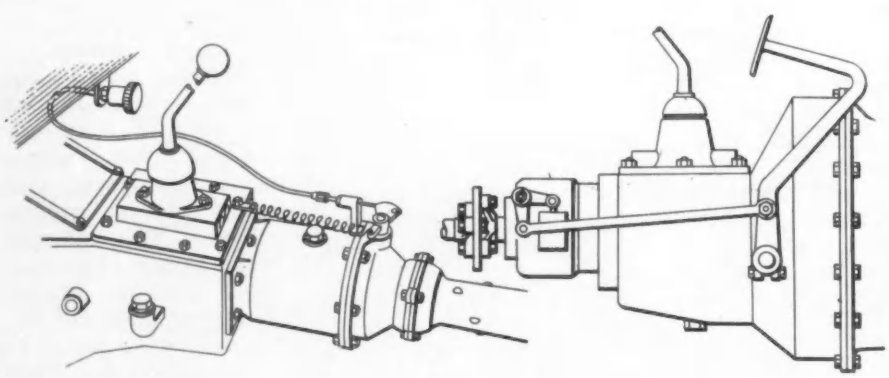


FIG. 3—TWO FREE-WHEEL CLUTCHES MOUNTED BACK OF THE TRANSMISSION

The Clutch at the Left Is Controlled by a Button on the Instrument Board; That at the Right Is Interconnected with the Clutch Pedal

Detail Design of One-Way Clutches

Considerable attention has been given to the detail design of the overrunning clutches. The multiple-roller cam type has been the most

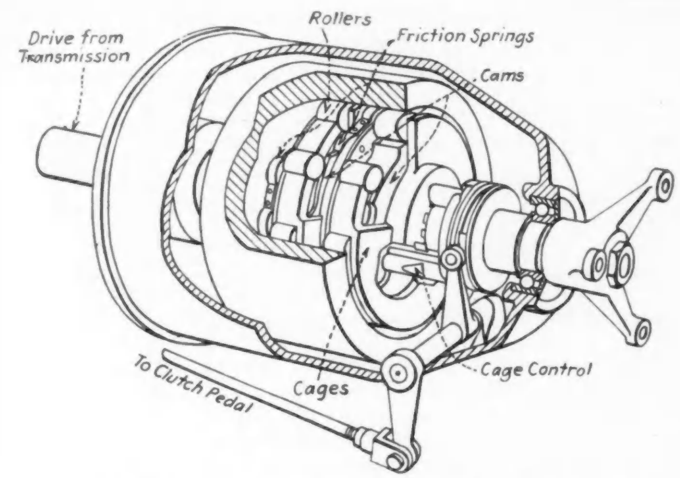


FIG. 6—DETAILS OF JOSEPH FREE-WHEEL CLUTCH

popular of the several types with designers. The Joseph design, shown in Fig. 6, utilizes two opposed multiple-roller cam-type clutches arranged so that one of them can be rendered inoperative by angularly shifting the roller cages. This design is used at the rear of the transmission. One unit transmits driving torque and the second, which is normally held out of engagement to allow free-wheel operation in all forward speeds, provides for reversing or using the engine as a brake when descending long grades. The second unit is brought into action by manual control.

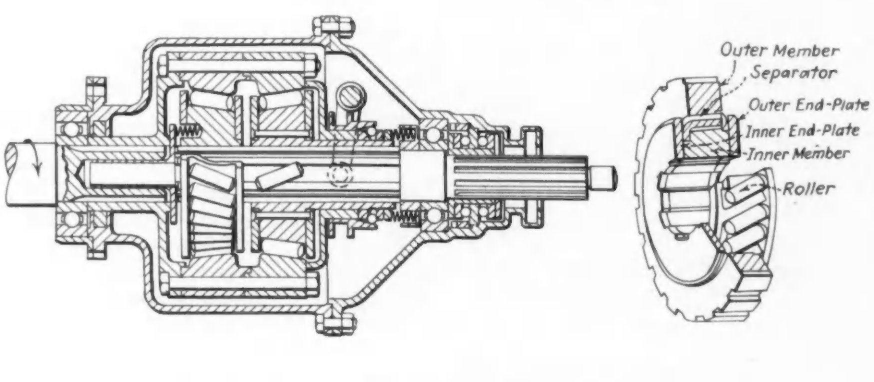


FIG. 7—HUMFREY-SANDBERG FREE-WHEEL CLUTCH
Locking Action Is Secured by the Angular Placing of Cylindrical Rollers between Conoidal Surfaces

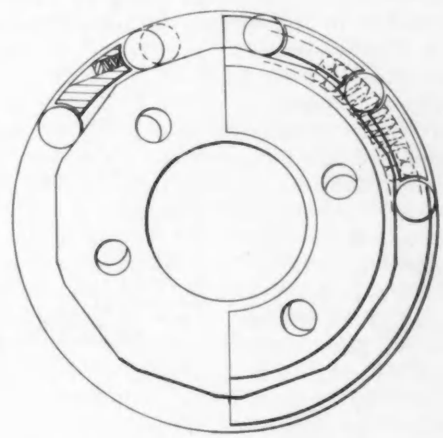


FIG. 8—DETAIL OF FARLEY ROLLER-CLUTCH

Fig. 7 shows the Humfrey-Sandberg design in which, also, two opposed multiple-roller units are placed behind the transmission. The peculiarity of this design is that the rollers, instead of operating on cam surfaces, are placed on an angle with the axis and operate between conoidal surfaces formed to give line contact with the rollers, which are straight. In one direction of rotation, these rollers act to draw the inner member into the outer member axially, resulting in a wedging action which causes the drive. Reversing the torque frees the clutch. This design requires an auxiliary manual control for reversing or using the engine for braking. A single unit of the same type is used in an industrial application for measuring small charges of powder. Fig. 8 is the clutch used in the Farley free-wheel transmission. A very similar construction is used in the Toothill unidirectional-drive unit as applied to the rear of a Jowett transmission, and it is representative of many designs.

Another type of roller clutch is shown in Fig. 9, this being the design of the Millam free-wheel device as applied to the Arrol-Aster chassis. The multiple-roller clutch used in the Constantinesco automatic transmission is shown in Fig. 10. This is particularly interesting because of the high capacity obtained, but its design seems not to lend itself to a compact installation.

Departing from the more common type of roller clutches, we note the pawl or lever type as found in the Pitter shown in Fig. 11. This clutch, which also has met with considerable success in industrial service, makes use of a very ingenious toggle action. Another interesting development is the L. G. S. coil-spring clutch, the central element of which is shown in Fig. 12 and an automobile application in Fig. 13. This device is similar in operation to the original Mercedes ribbon clutch, only that the spring in this case is coiled inside the cylindrical member instead of outside. Driving torque expands the spring, which normally is slightly smaller in diameter than the bore of the housing,

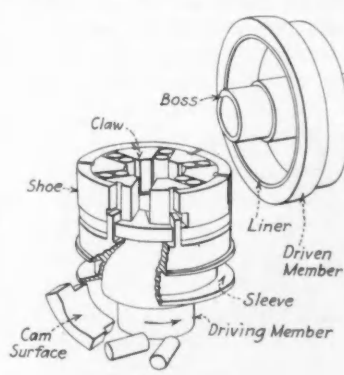


FIG. 9—MILLAM FREE-WHEEL MECHANISM
In This Device, Which Is Optional Equipment on the Arrol-Aster Chassis, Clutch Shoes Having Interior Double-Cam Surfaces Are Pressed Outward by Pairs of Rollers Actuated by a Segmental Claw Projecting from the Driving Member. The Rollers Abut against a Central Boss Which Is Integral with the Driven Member. Tongues Projecting from a Sleeve Normally Limit the Device to One-Way Action

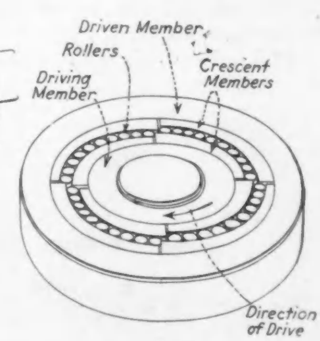


FIG. 10—ONE-DIRECTION CLUTCH USED IN CONSTANTINESCO AUTOMATIC TRANSMISSION

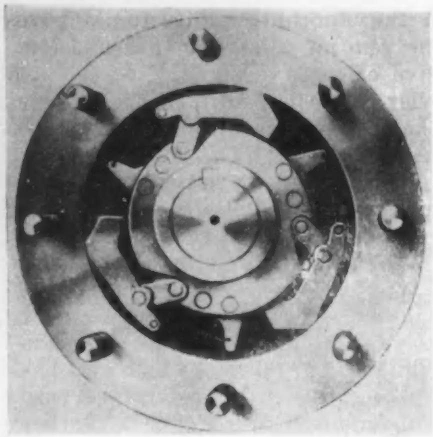


FIG. 11—PITTER INDUSTRIAL ONE-WAY CLUTCH

causing it to grip in both the driving and driven members. Incidentally, that Mercedes clutch would transmit power in one direction only; therefore, the first Mercedes cars imported into this Country embodied the free-wheeling principle.

Inventors of free-wheel devices, as can be seen from the foregoing brief outline, have attempted to secure either economy in the operation of the car or easy gear-shifting. Both of these results have been secured in the design developed by Studebaker, shown in Fig. 14, which provides for free-wheel operation in high and intermediate gears. The free-wheel or overrunning clutch is incorporated in this design as a shifting unit splined to the main shaft and serving to complete the high-gear or second-gear connection. Otherwise the transmission is quite similar to a conventional transmission except that the second-speed gear is constantly in mesh and runs free on the main shaft, being positioned axially by a thrust collar that is attached by a bayonet lock.

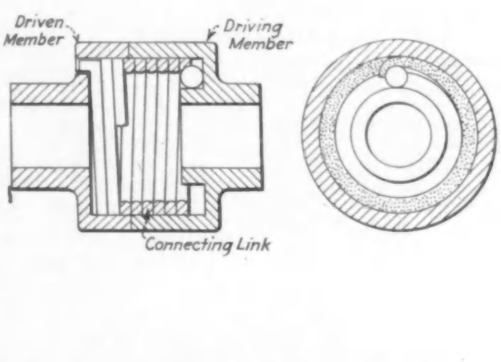


FIG. 12—L. G. S. COIL-SPRING ONE-WAY-CLUTCH ELEMENT

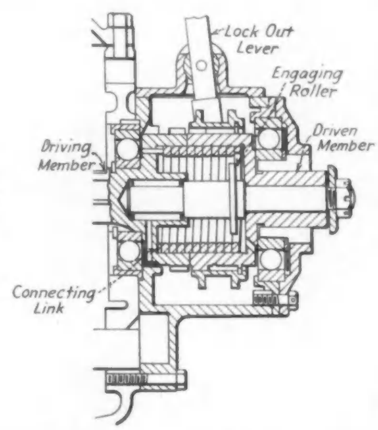


FIG. 13—L. G. S. CLUTCH APPLIED TO TRANSMISSION

Fig. 15 is an end section of the free-wheel unit,

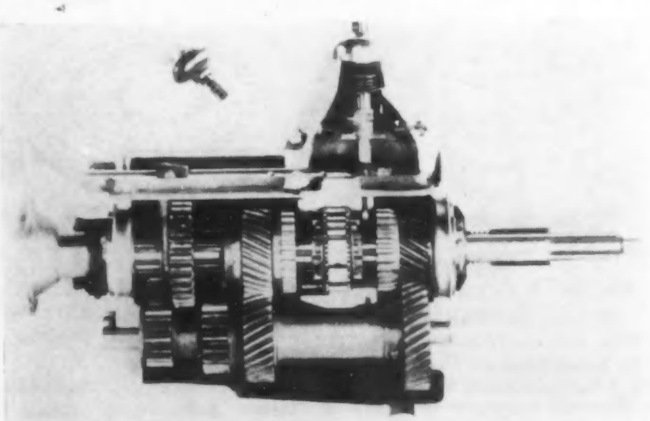


FIG. 14—STUDEBAKER TRANSMISSION EMBODYING FREE-WHEEL DRIVE

TABLE 1—EFFECT OF FREE-WHEELING ON DECELERATION IN BRAKING

Initial Car-Speed, M.P.H.	Pedal Pressure, Lb.	Stopping Time: Free-Wheel, Sec.	Stopping Time: Conventional, Sec.	Ratio
30	50	22.15	19.05	1.16
30	55	18.72		
30	100	5.53	5.36	1.03
30	105	5.14		
60	100	9.52	10.31	0.92
30	200	26.7[a]	24.0[a]	0.90

[a] Deceleration, feet per second per second.

which consists of a three-lobed inner cam, splined to the main shaft, an outer ring, and three sets of four rollers each, graduated in diameter to conform to the cam profile. Dimensions of the cam and rollers are given at the right in Fig. 15. The cam curve is a true arc of a circle. The wedging angle of the largest and the smallest rollers are, respectively, 3 deg. 40 min. and 8 deg. 45 min.

Internal teeth are provided at both ends of the outer member for engagement with corresponding clutch members attached to the main-drive and second-speed gears. External teeth are also provided at both ends of the inner cam-member, for engagement with corresponding internal clutch members on the main-drive and second-speed gears. The axial dimensions of these two sets of gear clutches are such that the outer member can be moved into engagement with either the main-drive or second-speed gears without bringing the inner-member clutch into engagement. In these positions, the drive is transmitted only through the overrunning clutch, with resultant free-wheel operation. Further axial movement of the free-wheel unit will bring the inner-cam member into positively clutched engagement with the direct-drive or second-speed gears, thus rendering the overrunning clutch inoperative. Fig. 16 shows the free-wheel unit diagramatically in both the free-wheel and the positive-drive position for second speed, corresponding high-gear positions being obtained by shifting in the opposite direction. Movement of the gearshift lever normally is limited by a stop so that the lever will be moved only to the second-speed or high-gear free-wheel position. Depressing a button in the top of the shift-lever ball allows engagement of either positive-drive clutch by further movement of the lever. The latch button may be held down and the transmission shifted directly into positive engagement in the conventional manner when the free-wheel device is not desired.

During the development of the overrunning clutch used by Studebaker an interesting series of tests was carried out on the chassis dynamometer to establish its

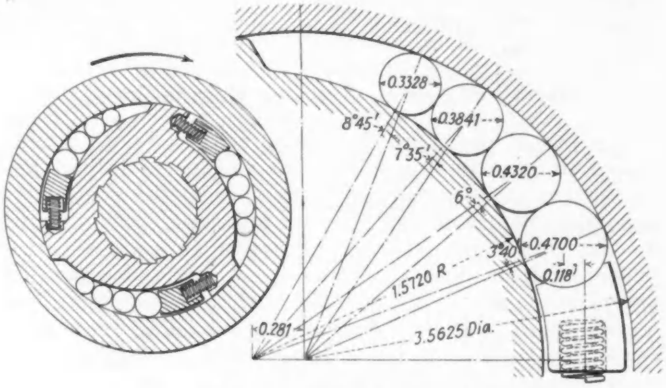


FIG. 15—STUDEBAKER ROLLER-CLUTCH

A Section from the Clutch Element Is Shown at the Left; Detailed Dimensions of the Clutch Elements Are Shown at the Right

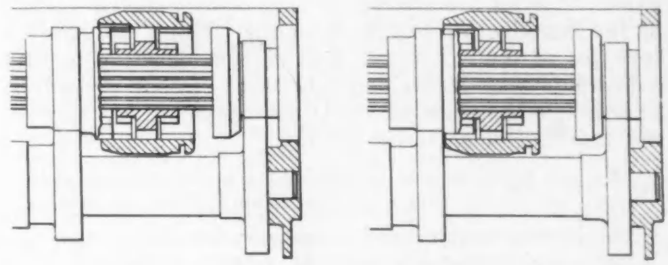


FIG. 16—POSITIONS OF STUDEBAKER CLUTCH FOR SECOND-SPEED DRIVE

The Position Shown at the Left Gives Free-Wheel Action. Further Motion of the Gearshift Lever Places the Unit in the Position Shown at the Right, in Which the Inner Clutch Is Engaged and the Drive Is Positive. Shifting the Unit Forward instead of Backward Gives the High-Gear Free-Wheel and Positive Drives

durability. A car equipped with the free-wheel transmission was operated on the following cycle by an automatic throttle-control in second gear: Starting with the car free-wheeling at a speed of 20 m.p.h. and the engine idling, the throttle was suddenly opened fully and held in this position until the car speed reached 30 m.p.h. At this time the throttle was closed and the car free-wheeled until the car speed had again dropped to 20 m.p.h., when the cycle was repeated. During this cycle the dynamometer was loaded to the equivalent of a 5-per cent grade. This test was applied to various designs of free-wheel units to determine the best cam-angles and the required roller-capacity. It was found that the unit adopted in the final design would operate successfully and with practically no wear on the rolls, cam or roll race for 50,000 cycles with only three rolls of any one size in place, the other nine rolls being omitted.

Before the design was released to production, cars equipped with free-wheel transmissions were submitted to many State motor-vehicle officials for trial and comment. Without exception the approval was unanimous and enthusiastic. The legal status of free-wheeling was unquestioned when applied in this way and combined with the ability to shift easily into a positive gear at any car speed.

The first new sensation in driving a free-wheeling car is that of a very freely rolling vehicle. This feeling is quite pronounced when the throttle is closed after accelerating in second gear. The feeling is much the same at high car-speed. The car rolls along with almost the sensation of increased speed at first; and then, when the engine noises have dropped to those of idling speed, the car seems to be moving much slower than its actual speed. In general, the consciousness of ability to turn the power of the engine on and off is greatly increased, and the feeling that the car is a freely rolling vehicle is immediately evidenced.

TABLE 2—EFFECT OF FREE-WHEELING ON NUMBER OF BRAKE APPLICATIONS

Nature of Road	Mileage	Average Speed, M.P.H.	Brake Applications Free-Wheel	Brake Applications Conventional	Ratio
Mountainous	3,061	30.2	4,392	3,798	1.16
Level	600	28.9	305	305	1.00
Mixed	541	39.8	965	846	1.14
City	158.5	10.1	2,216	2,465	0.90
				Average	1.05

Gear noise is barely noticeable when helical gears are used for second-speed driving, with the result that second can frequently be used continuously in traffic. The car can be started in second, rapidly accelerated and allowed to coast to the next stop without shifting. When free-wheeling, there is no more noise in second gear than in high. Declutching is unnecessary if the traffic light turns green before the car comes to a stop, and the cycle can be repeated from block to block with no other operation than manipulating the accelerator. It is entirely possible to keep up with traffic through almost the whole of New York City in one gear.

Gears can be shifted back and forth between second and high without declutching when free-wheeling at any car speed. This feature is found particularly pleasing in that it greatly reduces fatigue of the clutch foot and allows preselection of high or intermediate gear in anticipation of traffic or road conditions. It is no longer necessary to acquire the skill essential to double clutching or to bring the car nearly to a stop before shifting from high to second gear. In negotiating grades or heavy going, the change from high to second can be made while the car is travelling at a higher speed, before its momentum has been lost. This feature appeals alike to both skilled and unskilled drivers.

Some items in car construction naturally require alteration to meet the new conditions when its operating

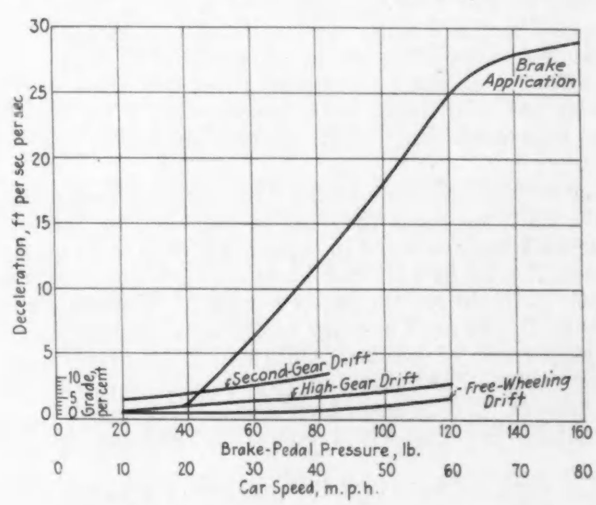


FIG. 17—ANALYSIS OF SOURCES OF DECELERATION

characteristics are altered by such a deep-seated change as the introduction of free-wheeling. Units and characteristics of the car which require consideration in this connection may be divided into three classes, according to whether they are affected favorably, unfavorably or not materially by free-wheeling.

(1) The requirements of the brakes and generator are increased, and structural changes are desirable.

(2) Improvements result in fuel economy, oil economy and engine life; and the service of the clutch, propeller-shaft, rear axle and tires is reduced by free-wheeling, so that the performance is improved without structural changes.

(3) The effects on engine-cooling and idling are self-compensating, so that no structural changes are required.

There is no question that the use of free-wheeling increases the severity of brake service, but this increase is much less than is generally believed. An increase in brake capacity of 20 per cent has been found to be more than ample to take care of free-wheel conditions.

The relative braking effectiveness of the engine and the wheel brakes is shown in Fig. 17, in which rolling and wind resistance of a free-wheeling car, expressed as deceleration in feet per second per second, is shown together with similar curves including the engine friction in direct drive and second speed with closed throttle. The upper line shows the car deceleration for the full range of pedal pressures. The stopping rates are for all practical purposes independent of car speed. Inspection of these curves shows at once that the braking effect of the engine is very small when compared to that of the wheel brakes. These data give a fairly accurate idea of conditions for braking on hills where the speed is held down to a desired maximum.

Conditions are not the same, however, during a normal stop on a level road, and the difference becomes greater and greater at the higher decelerations. Under these conditions, the engine must slow down to idling speed more rapidly than the car is stopping if it is to be of assistance to the brakes. Furthermore, if the stopping rate is fast enough so that the tires mark the road or the wheels lock, the engine must be slowed down rapidly or stopped almost instantly by the brakes. In these cases the brakes must stop the engine as well as the car. Table 1 gives the average results from nearly 100 runs made to determine the influence of engine friction on the braking ability of a car. These data indicate that the engine is of assistance in stopping the car at low rates of deceleration, but that it is less and less effective at higher stopping rates and from higher speeds. An additional pedal pressure of 5 lb. slightly more than made up for the absence of engine-braking effect.

Counting brake applications while driving under identical conditions gave the results recorded in Table 2. These data were secured in connection with tests on fuel consumption by driving two identical cars, one following the other, in the mountainous region of Western Pennsylvania, in the level country of Indiana, on mixed level and hilly roads of Indiana, Ohio and Pennsylvania, and in city traffic. The individual characteristics of the cars and drivers were canceled out, as far as possible, by alternating the free-wheel operation between the two cars.

These data indicate that the number of brake applications in hilly country is about 16 per cent greater with free-wheel operation than with a conventional transmission. The difference is much less on level roads and in traffic.

Effects of Lower Average Engine-Speed

Free-wheel operation in traffic, with a resulting increase in time during which the engine is idling, decreases the ampere-hours of charge from the generator. Readings on cars driven through the same traffic during the day and night showed a decrease in ampere-hours charge of from 5 to 15 per cent. A slight decrease in generator-pulley size, together with the fact that the engine speed is higher during free-wheeling than during ordinary idling, more than compensates for this ampere-hour loss in charging.

It might seem that the engine-idling requirements would be more severe with free-wheeling. However,

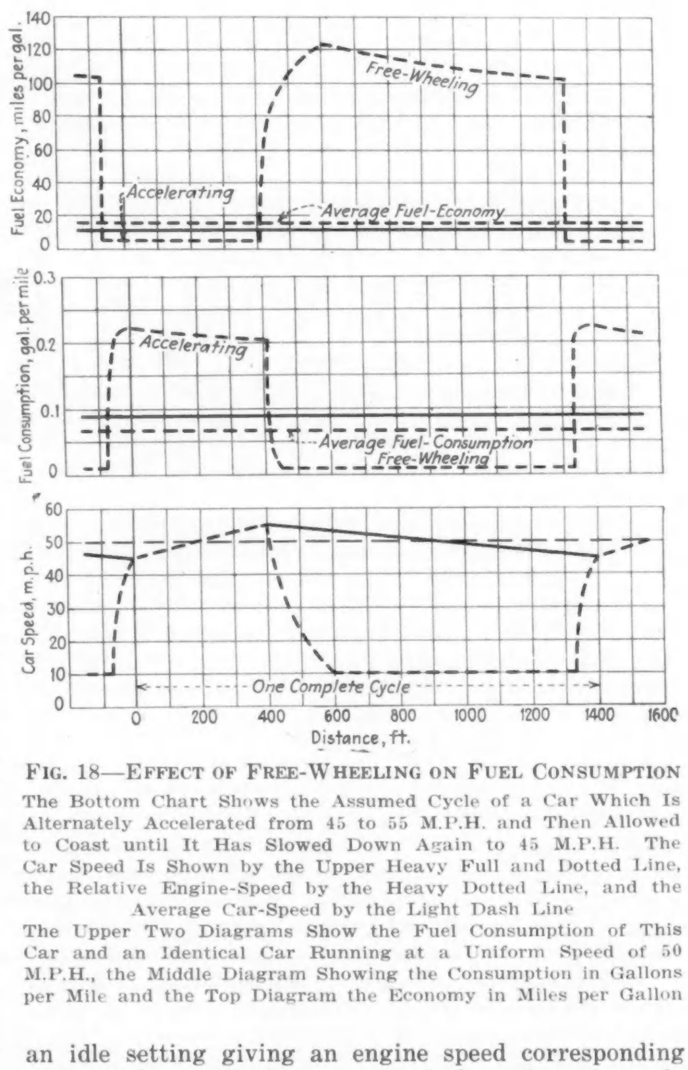


FIG. 18—EFFECT OF FREE-WHEELING ON FUEL CONSUMPTION

The Bottom Chart Shows the Assumed Cycle of a Car Which Is Alternately Accelerated from 45 to 55 M.P.H. and Then Allowed to Coast until It Has Slowed Down Again to 45 M.P.H. The Car Speed Is Shown by the Upper Heavy Full and Dotted Line, the Relative Engine-Speed by the Heavy Dotted Line, and the Average Car-Speed by the Light Dash Line

The Upper Two Diagrams Show the Fuel Consumption of This Car and an Identical Car Running at a Uniform Speed of 50 M.P.H., the Middle Diagram Showing the Consumption in Gallons per Mile and the Top Diagram the Economy in Miles per Gallon

an idle setting giving an engine speed corresponding to 5 m.p.h. results in a speed of about 8 to 9 m.p.h. during free-wheeling. The need for stability therefore does not affect the idle setting required.

A similar situation obtains in the matter of cooling, and no allowance need be made for cooling when free-wheeling under normal operating conditions. In the extreme case of a car which is driven wide open for some distance and then free-wheels for a long time with the pump running only at engine-idling speed, the residual heat may be sufficient to cause an appreciable rise

in water temperature. This condition is not encountered often, because a car ordinarily is accelerated frequently during fast driving. With conventional transmissions it is not at all uncommon to have a radiator "gush over" when hard driving is followed by an application of the brakes. Any difficulty encountered on this score during warm weather is offset by the improved performance of the cooling system in cold weather. The average fan speed when free-wheeling is lower than with the conventional gear, and the water in the radiator therefore is at a higher average temperature.

Engine life is increased in proportion to the amount of free-wheeling done. This factor will vary with the individual owner, the character of the roads, and the traffic, but it is of more than minor importance.

Life of the clutch is materially increased by free-wheeling, because the clutch is used less frequently. It is not necessary to release the clutch after starting in low gear and shifting to second unless the car is brought to a speed lower than that corresponding to the idling speed of the engine, shifts between second and high being made by releasing the accelerator. Elimination of coasting loads also reduces the wear on the tortional-damper assembly in the clutch.

Transmission gears and bearings also benefit by the elimination of coasting loads. Gear noise is entirely eliminated when free-wheeling in second gear. Elimination of coasting loads on the propeller-shaft, rear axle and tires is also of considerable importance.

Considerable Saving in Fuel Is Possible

To illustrate the maximum possible fuel-saving resulting from free-wheeling, let us consider the theoretical case of two otherwise identical cars, one equipped with a conventional transmission and the other with a free-wheel transmission. The conventional car is operated at a uniform speed of 50 m.p.h. on a level road, as indicated by the light dotted line in the lower graph of Fig. 18. The other car, equipped with a free-wheel transmission, is operated at the same average speed by accelerating at full throttle from 45 to 55 m.p.h., then allowing the car to free-wheel with the engine idling until the car speed has again dropped to 45 m.p.h. The free-wheel car will be found to accelerate from 45 to 55 m.p.h. in approximately 400 ft. and to drift from 55 to 45 m.p.h. in approximately 1000 ft. The heavy dotted line in the lower diagram shows the engine speed of the free-wheel car during this cycle, expressed in terms of car miles per hour.

The middle diagram of Fig. 18 shows the fuel consumption of the two cars for one complete cycle such as has been described. The car equipped with a conventional transmission, traveling at a uniform speed of 50 m.p.h., consumes 0.087 gal. per mile. The dotted line shows the fuel consumption of the free-wheel car at any time during the cycle. The fuel consumption reaches a rate of nearly 0.225 gal. per mile at the start of the acceleration interval, gradually decreasing, as the speed increases, to approximately 0.2 gal. per mile when the car speed reaches 55 m.p.h. The throttle is then closed, allowing the engine to idle down to a speed corresponding to approximately 10 m.p.h., with a correspondingly low fuel-consumption of 0.01 gal. per mile. The engine then idles at this greatly reduced fuel consumption while the car is slowing down to 45 m.p.h., for approximately 1000 ft., and the cycle is again repeated. The average fuel-consumption is found to be 0.066 gal. per mile while the free-wheel car travels the 1400 ft. This saving of 0.021 gal. per mile is a reduction of slightly more than 24 per cent in the fuel consumed under the foregoing conditions.

The upper diagram of Fig. 18 shows the fuel consumption translated into fuel economy, expressed in miles per gallon. The results here are somewhat surprising, although likely to be misleading. Whereas the conventional car operates uniformly at 11 miles per gal., the free-wheel car consumes fuel at the rate of 4 miles per gal. while accelerating from 45 to 55 m.p.h. at full throttle, and yet it reaches the astonishing figure of over 100 miles per gal. during much of the time while it is free-wheeling. The average for the 1400-ft. cycle of operation is found to be approximately 15 miles per gal.

A simple example may help to explain why the average seems low. If a car runs 100 miles at 10 miles per gal. and then another 100 miles at 100 miles per gal., the average mileage for the 200 miles is not 55 but 18.2 miles per gal. Ten gallons are used in the first 100 miles and 1 gal. during the next 100 miles, making a total of 11 gal. for the 200 miles, or 18.2 miles per gal.

TABLE 3—ESTIMATED MAXIMUM SAVING IN FUEL FROM FREE-WHEELING

Speed of Conventional Car, M.P.H.	Speed Range of Free-Wheel Car, M.P.H.	Maximum Saving,[b] Per Cent
50	40–60	24–29
50	45–55	23–27
30	25–35	27–42
20	15–25	26–50

[b] The variation in fuel saving shown indicates the effect of fuel consumption during idling.

A similar analysis at average speeds of 20 and 30 m.p.h. gives the results shown in Table 3.

Fuel Saving Demonstrated by Road Test

The actual saving in fuel and oil which can be credited to free-wheeling is, of course, determined to a large extent by the character of the roads, traffic conditions and the personal habits of the driver. To check the possible differences in gasoline consumption as estimated by the method just outlined, both in mountains and in level country, accurate records of gasoline and oil consumption were kept on two sedans while they were driven on the main roads in Western Pennsylvania and Indiana. The cars were identical in every respect, and both were equipped with transmissions which could be operated either free-wheel or in the conventional manner. The two cars trailed one another, one free-wheeling and the other in conventional gear, at a speed of approximately 30 m.p.h. This speed was maintained both up and down grade with the exception that the free-wheel car was allowed to coast down grades, brakes being used only as necessary for safety. Always the leading car was operated free-wheel and the trailing car in conventional engagement. On alternate days the free-wheeling and conventional methods of operation were alternated between the two cars, to eliminate any other possible difference, although the differences in fuel and oil consumption with both cars free-wheeling over the same course were found by test to be negligible. Routes were selected which could be completed in one day, and they were repeated on the following day with the two cars reversed in method of operation. This procedure

TABLE 4—OBSERVED SAVINGS OF GASOLINE AND OIL

		Gasoline Consumption				Oil Consumption			
		Miles per Gal.		Per Cent		Miles per Gal.		Per Cent	
Miles	Speed, M.P.H.	Conventional	Free Wheeling	Increase in Mileage	Decrease in Consumption	Conventional	Free-Wheeling	Increase in Mileage	Decrease in Consumption
				On Mountainous Roads					
627	28.9	13.6	16.3	20	16.5	1,255	3,350	167	62.5
555	29.8	13.3	15.9	19.5	16	1,360	1,770	30	22
528	30.0	13.4	16.4	22.5	18.5	1,020	1,880	84	41.5
533	29.8	13.3	16.1	21	17.5	1,700	1,220	–28[c]	–39[d]
306	32.0	13.1	16.5	26	20.5	890	1,090	22.5	18.5
511	30.8	13.8	16.4	19	15.5	1,090	2,340	115	56
				Averages for Mountainous Roads					
3,060	30.2	13.5	16.3	21	17.5	1,219	1,942	59	38
				On Level Roads					
600	28.8	16.5	21.6	30.5	23	1,920	2,750	43	30
530	42.7	12.8	15.1	18.5	16	400	1,490	270	68.5
				In Traffic					
318	10.3	9.2	10.3	12	10.5	790	900	14	12

[c] Decrease.
[d] Increase.

was followed for 12 days, over a total of 3060 miles.

The road selected for the level-country tests was on Route 31 between South Bend and Indianapolis. The route for traffic driving was selected in South Bend, so as to include as many traffic stops as possible. The results of these tests are detailed in Table 4.

THE DISCUSSION AT NEW YORK

THOMAS J. LÍTLE, JR.[3]:—Free-wheeling is a subject that has occupied the attention of many progressive engineers; surely one possessed with only ordinary vision can see the advantages to be attained from it. I personally see a great deal in this device other than sales novelty, which in too many cases has been the deciding factor in engineering innovation.

History is repeating itself in this respect, as at many other times in the mechanical arts. Harking back to the bicycle days, we remember the introduction of the coaster-brake and its remarkable success. It looks to me as though this procedure would be repeated with the overrunning clutch or free-wheeling device.

It certainly seems strange that so much time should elapse in transposing an accepted mechanical success from one industry to another.

We in America seem to have become obsessed with the idea of standardization, which is a perfectly natural and logical procedure in relation to accessories and hardware, but should not be countenanced in engine design or in coach work. It has become extremely difficult for the uninitiated to distinguish one current automobile from another, and almost as difficult to differentiate between some of our automotive powerplants. It is refreshing indeed to see manufacturers step out and sponsor a radical development.

THOMAS J. LÍTLE, JR.

E. R. FISH[4]:—Free-wheeling seems unnecessary provided the transmission incorporates gear-reduction ratios designed on the basis of synchronizing vehicle speed with engine speed when the maximum point of vehicle acceleration and engine efficiency is nearly approached for each gear ratio.

However, the free-wheeling idea undoubtedly introduces an advantage from the selling angle and creates curiosity and attention on the part of potential purchasers of new cars.

FREDERICK S. DUESENBERG[5]:—I have been interested in free-wheeling and built a car embodying it for my own personal use four years ago. This device, however, was not as perfect as some of those we have tried since. We have had several on cars during the last 12 months that are operating very satisfactorily.

Free-wheeling encounters a general trend of opposition, but I feel that all of this can and will be overcome and that free-wheeling will add a great deal to the life of the engine and other automobile parts. It certainly is capable of increasing gasoline mileage from 15 to 20 per cent. It will be a tremendous advantage excepting possibly in crowded city driving and a few other localities. I think that free-wheeling has come to stay.

F. E. WATTS[6]:—As a strictly personal opinion, I will say that I like free-wheeling, based on about 10,000 miles of driving with various types of free-wheeling cars during the last two years, but the final reaction to free-wheeling will not be known until the public has had experience with its use during the coming winter.

E. S. MARKS[7]:—Although we have been driving free-wheel cars for many months, I have learned some new points about them at this meeting. Like every other

[3] M.S.A.E.—Engineer and industrialist, Director of engineering, Holley Carburetor Co., Detroit.
[4] M.S.A.E.—Transmission engineer, Brown-Lipe Gear Co., Syracuse, N. Y.
[5] M.S.A.E.—Vice-president in charge of engineering, Duesenberg, Inc., Indianapolis.
[6] M.S.A.E.—Chief engineer, Hupp Motor Car Corp., Detroit.
[7] M.S.A.E.—Chief engineer, H. H. Franklin Mfg. Co., Syracuse, N. Y.

engineering problem, free-wheeling has both advantages and disadvantages, and our job is to find out which predominate. When the industry is sure that the advantages of any new device overbalance its disadvantages the logical action follows. Free-wheeling certainly has many advantages; gear-shifting with it is a revelation.

We are apt to be guided in our work by personal opinions. To prevent the predominance of such opinions, we like to have various people drive our cars, to secure their opinions as laymen. Such experiences have brought up some questions which I should like to pass on to Mr. Roos.

DELMAR G. ROOS

When the car is free-wheeling at high speed, there is a noticeable lapse between pressing the accelerator and the time when the engine begins to drive the car. Has this come to Mr. Roos's attention? Many people like to have the idling speed of the engine quite low. When free-wheeling, it is desirable to be sure that the engine will not stall, so that its power will be available always. Is it not therefore necessary to make the idling speed a little higher than it would be with the conventional transmission, and is not this higher idling speed noticeable when the car is standing still?

Intermittent or fluctuating noise sometimes is more noticeable than continuous noise. The continuous noise of an engine may not be noticed as much as the same amount of noise will be noticed after the engine has been absolutely quiet. Has this condition caused any serious criticism?

Faster Idling Prevents Engine Stalling

DELMAR G. ROOS:—The lapse of time before the engine picks up at high speed is noticeable, but I never heard of any objection being offered on that score. There is no sign of a jump; the acceleration of the engine is heard, and suddenly the driver becomes conscious that the car is being pulled again.

Faster idling is not necessary, but it is desirable to set the idling speed about 2 m.p.h. faster than it would be with a conventional transmission. We set it at a speed corresponding to about 8 m.p.h., which gives an actual car-speed of about 5 m.p.h. in traffic. This avoids the range of instability in carburetion and prevents the engine from stalling. In case the engine does stall, it is possible to shift our transmission into positive gear under conditions under which no ordinary transmission could possibly be shifted into second or high.

As Mr. Marks pointed out, good engineering always requires compromises, yielding something in order to gain something else. There has been no criticism of our idling speed, and what we have gained seems to be well worth the slight sacrifice in that direction.

Mr. Marks is right about the contrast in noise. That contrast increases the use of free-wheeling; the driver gets to enjoy the delightful sensation of gliding along the road without sound, and he does it as often as he can. When we arrive at the point where the engine is as quiet under power as during free-wheeling, there may not be so much employment of free-wheeling by the drivers.

E. T. BIRDSALL[8]:—It is hard enough to keep the battery charge up during the winter when a conventional transmission is used. It must be even harder with free-wheeling. I have not driven a free-wheeling car, but I think I should like it, as I frequently coast with the clutch out.

Safety in Descending Hills

JOSEPH A. ANGLADA[9]:—My experience with roller-clutches has been that eventually grit in the lubricant acts as a lap between the rollers and the surfaces with which they contact, wearing depressions which prevent the rollers from operating. Mr. Roos undoubtedly has been able to develop manufacturing processes and heat-treatments which overcome that difficulty, and I wish to congratulate him for that.

What happens when the foolish driver suddenly realizes, while free-wheeling down a hill, that he wishes to have a positive drive, and presses the button and pushes the positive clutch into engagement without de-clutching the engine? Is there not a tendency to stress the driving mechanism excessively?

MR. ROOS:—The conditions are infinitely better than if the driver wishes to change from high to second gear while going down a mountain grade with an ordinary transmission. If the driver permits himself to attain excessive speed under those conditions and has no effective brakes, he will get into trouble with almost any type of car. It is possible to shift into positive engagement when it would be impossible to shift from high into second with a conventional transmission. If the driver fails to accelerate the engine before doing this, there may be a clashing sound; but he can make the shift, which is more than can be said of the conventional transmission. To that extent, the device is much safer, and we were able to demonstrate this point to the satisfaction of the various motor-vehicle commissioners throughout the Country.

Much research and development work contributed to the design of our roller clutch, involving heat-treatments, lubrication and unit pressures. It cannot be said that any mechanical device will be absolutely free from trouble — we still hear complaints about things like piston slap—but the cycle tests reported in the paper indicate that the life of the clutch is extremely satisfactory, and the experience we have had so far with the device in the hands of our customers has confirmed this.

E. S. MARKS

As stated in the paper, free-wheeling affects the generator output adversely. Motor-cars equipped with integrating wattmeter were operated for a long time

[8] M.S.A.E.—Chief engineer, Lawrence Engineering & Research Corp., New York City.

[9] M.S.A.E.—President, Anglada Motor Corp., New York City.

JOSEPH A. ANGLADA

both by us and by the Delco-Remy Corp. to determine the difference, and a slight increase in generator speed and a slight change in the third-brush setting have been sufficient to make the generator output at least equivalent to that on a car operating in the conventional way.

F. C. MOCK[10]: — Carbureter men, I think, were somewhat worried at the introduction of free-wheeling, anticipating trouble with the engine because of stalling when suddenly relieved of a heavy load at low speed. This, however, is something that we have had in the past. Under certain exigencies of driving—such as starting to accelerate rapidly from a low speed and then, due to a traffic emergency, releasing the accelerator, throwing out the clutch and applying the brakes hard—the engine will often stall, provided that the adjustment is such that the car will idle at 2 to 3 m.p.h. in high gear. This difficulty is due to the abnormal air and fuel-vapor densities existing in the inlet manifold after such a maneuver, and it is most easily cured, as Mr. Roos suggests, by setting the throttle stop to give a slightly faster idling speed.

CARL W. WEISS[11]:—Has Mr. Roos had any experience with the Constantinesco type of clutch shown in Fig. 10? Clutches of this type have been in use for a number of years, and I believe that it is one of the best one-way clutches that ever were made. It was originally used on the Otto-Langen free-piston gas engine in 1870.

MR. ROOS:—I have had no experience with a clutch of that type. I believe that it might have decided merit, but it is questionable whether it could be made successfully within the space limitations of an ordinary transmission case.

Early Electric Drives Gave Free-Wheeling

FREDRICK E. MOSKOVICS[12]:—I have driven what I suppose was the first free-wheel car in the world. It was a Lona-Porsch, which had an electric motor in each wheel. That was made 30 years ago, and was a delightful car to drive. I worked in the drafting department of the factory where it was built.

Free-wheeling was the greatest charm of the Owen magnetic car. I have driven probably 15,000 miles in Europe with free-wheel devices of various types. The last one of these was one in which the late Sir Henry Segrave was interested. He lent one of the cars to C. F. Kettering and me three years ago, and we drove all over London with it.

Mr. Roos is to be censured severely for one thing; what he has done will probably make it necessary for some engineers to go to work. We should have not only free-wheeling but free spring-suspension and a hundred other improvements; and, to get the full advantage of the possible 100 miles per gallon from free-wheeling, we should have the roads made so that all of them are down hill.

CARL F. SCOTT[13]:—Are the Studebaker free-wheel cars equipped with three-speed or four-speed transmissions?

MR. ROOS:—They are equipped with three-speed transmissions. Four-speed transmissions seem to us to have some disadvantages that have deterred us from using them. We have provided for easy shifting and have made the second speed exceedingly quiet. The second-speed ratio has been changed from about 1.81 to 1.67-1.62 to 1. The gasoline and oil economy is at least as good as can be secured with a four-speed transmission and fast rear axle.

Of course the relative advantages of the four-speed transmission and the free-wheeling transmission are a matter of opinion, and the decision will be made by the public.

M. C. HORINE[14]:—Builders of heavy vehicles face a problem which is entirely different from that of the passenger-car. We have been building free-wheel motorcoaches for some years, and find the problem of brakes to be very difficult. Faced with limitations as to over-all width, the need of wide frames for stability, and reduction in rim diameter, the problem approaches the insoluble with friction brakes of the present type. This has been the experience of everyone who has built gasoline-electric motorcoaches.

While the free-wheel drive has provision for locking, it seems as if a man who has been living in a level country might be in serious trouble if he should find his brakes beginning to burn in say the mountains of Pennsylvania. Not having needed to use the engine as a brake previously, it might be hard for him to shift into the positive position.

MR. ROOS:—Mr. Horine would not say what he did if he had ever driven a free-wheeling Studebaker. Not the slightest difficulty was encountered by the motor-vehicle commissioners of the various States or by women who were asked to drive the automobiles without being told about the free-wheeling until they were out on the road.

Free-Wheeling for Heavy Vehicles

I am not at all sure that free-wheeling will not eventually find a place on commercial vehicles. If free-wheeling is dangerous for commercial cars, it is because the engine is disconnected from the wheels so that it is not used as a brake. Then why do not commercial vehicle engineers develop the pumping capacity of the engine for use as a brake? Doubling the pumping capacity would be easy under some conditions.

F. C. MOCK

MR. HORINE:—I think that Mr. Roos is right in suggesting that this should be done. The Saurer truck, which he mentioned in his paper, did this many years ago.

[10] M.S.A.E.—Engineer, Bendix Research Corp., East Orange, N. J.

[11] Chief engineer and vice-president, Weiss Engineering Corp., New York City.

[12] M.S.A.E.—President, Improved Products Corp., New York City.

[13] M.S.A.E.—Sales manager, Gurney Elevator Co., New York City.

[14] M.S.A.E.—Sales promotion manager, International Motor Co., Long Island City, N. Y.

and I believe the builders still use the same construction. Of course this practice arose among real mountains.

I am not pessimistic about free-wheeling for passenger-cars; and it can be adapted to heavy vehicles if that becomes desirable, but if this is done we will require a type of braking mechanism that is different from any that we now know.

WALTER S. PEPER[15]:—One of the chief complaints from motorcoach operators, according to my experience in charge of Eastern service for one large manufacturer, was excessive oil-consumption, particularly on hilly routes where the engine was used for long periods as a brake. The same conditions were found with passenger-cars, in which a high vacuum is caused in the manifold at the same time when oil pressure is kept high by the engine speed. Free-wheeling will prevent this condition, which causes oil-pumping.

Location and Lubrication of Free-Wheel Clutch

QUESTION:—What is the relative advantage of placing the free-wheel device at the differential or at the transmission?

MR. ROOS:—A free-wheel device at the differential cannot give the same advantage in gearshifting as can one in the transmission, because of the inertia of the parts between. One thing that made it possible for us to consider favorably the construction that we have adopted is the fact that the free-wheel device can be controlled through the gearshift lever.

W. E. JOHN[16]:—Does your experience lead you to think that some form of automatic transmission may be developed to eliminate the present gearshift?

MR. ROOS:—Such a development I believe to be only a question of time. Much commendable work has been done in that direction, and every attempt of the sort has been based upon a free-wheel clutch of some sort. I have not yet seen an automatic transmission that I think would be acceptable to the American public in its present form, but I think that such a development is coming.

F. C. MCMANUS[17]:—Are the internal surfaces of the overrunning clutch lubricated by the regular transmission oil; if so, is any difficulty encountered in cold weather?

MR. ROOS:—The free-wheel clutch is open to allow lubrication by the oil contained in the transmission case. It is necessary to follow definite specifications for the transmission lubricants. If excessively thick lubricant is used, the roller clutch will not operate in cold weather until the car has been driven for one or two blocks with the transmission in positive engagement. Even with such oil, the temperature rises quickly to a point where the roller clutch will operate. This trouble will not be encountered if the instruction-book specifications are followed.

THE DISCUSSION AT DAYTON

QUESTION:—Has any difficulty been encountered because of the great pressures in the roller clutch?

W. S. JAMES:—There has been no difficulty from rollers crushing or cases bursting during the severe tests reported in the paper or in service since. The shells are forged from 3.5-per cent nickel-steel, and all the parts are given good heat-treatment.

W. S. JAMES

F. W. SAMPSON[18]:—Is it not necessary to slow down the engine as well as the car when the free-wheeling car is stopped quickly?

MR. JAMES:—We have tried to measure the rate at which the engine decelerates, and find that it decelerates faster than the car except during very quick stops. When the car does catch up with the engine in its deceleration, the engine speed is so low that it is of little importance. About 0.2 sec. is required to move the foot from the accelerator to the foot-brake, and the engine will drop from 3600 r.p.m. to idling speed in about 1.8 sec.

A VISITOR:—Fig. 18 shows the fuel economy, in miles per gallon, to be falling during the free-wheeling operation of the cycle. What causes this?

MR. JAMES:—After the engine reaches idling speed, the fuel consumption measured in gallons per hour remains constant; but, as the car speed is dropping off, the miles per gallon are decreased.

MR. TIETSCHE[19]:—Does free-wheeling affect the tendency to skid?

MR. JAMES:—We have been unable definitely to detect any difference. I took a trip recently on icy roads; and this summer I drove 400 miles on a road which had about 20 curves to the mile. During the time I felt that the car took the curves easier when free-wheeling.

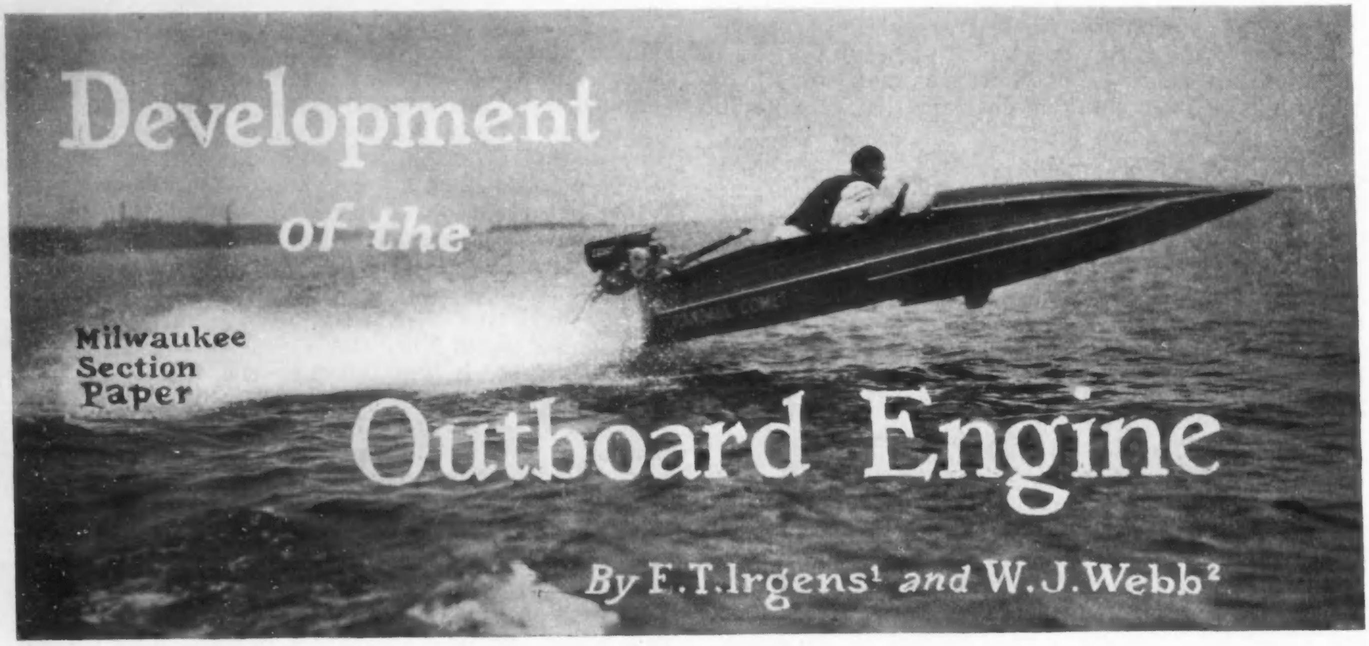
B. D. KUNKLE[20]:—Have you made any tests to show how many of the rollers in the clutch actually do sustain the load in service?

MR. JAMES:—Uniform engagement of all four rollers in each group is not secured in all cases. Usually three of the four are working, as shown by the marks on the cam. If one roller wears a little, the load is thrown on another; thus the load is distributed.

E. L. WELSH[21]:—Does the driver have as good control over the car in a tight place with free-wheeling as in normal operation; on a railroad crossing, for instance?

MR. JAMES:—I feel that I have better control, particularly in traffic, because I can shift without the use of the clutch. I can free-wheel up to a railroad crossing in second gear; then, if there is an emergency, the engine will give rapid acceleration with no danger of stalling while crossing the track.

[15] M.S.A.E.—Sales engineer, Bellanca Aircraft Corp., New York City.
[16] M.S.A.E.—Manager New York office, Sterling Engine Co., New York City.
[17] Jun. S.A.E.—General engineering department, International Motor Co., New York City.
[18] M.S.A.E.—Assistant chief engineer, Inland Mfg. Co., Dayton.
[19] Engineer, Riess Mfg. Co., Division Master Electric Co., Dayton.
[20] President and general manager, Delco-Products Corp., Dayton.
[21] Engineering department, Delco-Products Corp., Dayton.



TYPICAL OUTBOARD RACING BOAT IN ACTION

An Outboard Boat, Powered with an Elto Four-Sixty Engine Weighing 116 Lb. and Developing Nearly 45 Hp., Established an Official Record of 50.934 M.P.H. Last Year

OUTBOARD-ENGINE history is briefly reviewed by the authors, who then discuss at greater length the development in design and the remarkable results obtained in a period of 10 years.

Service engines are classified by cylinder capacity, weight and horsepower, and the more important requirements in outboard-engine construction are set forth. Several types of engine evolved to meet these requirements are distinguished by cycle of operation, number of cylinders, and port or valve system.

Improvements in methods of muffling the exhaust are discussed and the under-water-exhaust muffler is asserted to give higher speed than wide-open exhaust to the atmosphere.

Both battery and magneto ignition systems are used, the latter having been most satisfactory for racing until the year 1930, when the closed-circuit battery system took first place.

In response to the demand of boat owners, an electric engine-starter of the motor-generator type has been developed and applied.

Racing is credited with stimulating the development of many improvements that have been embodied in service outboard-engines. Racing engines are classified by racing rules according to piston displacement, and this is stated to have resulted in higher engine-speeds.

Means whereby horsepower per cubic inch of piston displacement and per pound of weight has been increased are reviewed, and the authors specify how the power developed is most efficiently applied, through the efforts of the engine and boat designers, to get the maximum speed out of the boat.

The phenomenal progress made in the last 10 years is summarized in comparative ratios of horsepower to piston displacement and engine weight, in engine speed in revolutions per minute and boat speed in miles per hour.

Points raised in the discussion relate to compression ratios, why the two-cycle principle is almost universally used, how the lubricating oil is mixed with the fuel, oil consumption, the factor that limits the engine speed, ratio of bore to stroke, why additional cylinders rather than larger cylinder size are used to get increased power, material used for pistons, use of antifriction bearings, and prevention of electrolysis.

AN OUTBOARD engine, in popular conception, consists of a portable two-cycle gasoline engine and a propeller unit, built for propelling all types of craft through water. Usually, this unit assembly is attached to the back, or transom, of a square-stern boat.

The outboard engine is not a new development. Some of the earlier patents on outboards expired long ago. Ole Evinrude, while not the originator of the idea, must be given credit for producing the first commercially and mechanically successful outboard engine, and to his creative genius a large percentage of all major outboard-engine improvements owe their origin.

We have every reason to believe that the first outboard engine was produced between 30 and 40 years ago. It was a steam engine, European in origin, and had a single large cylinder, which was clamped to the back of a square-stern flat-bottom boat. The boiler was stationary, inboard. Little is known of this type of engine except that it worked after a fashion and very few were produced.

Next came the electric outboard unit, which consisted of an electric motor screwed to the transom of a boat and driving a propeller, the power being furnished by storage batteries placed inboard. Considerable experimental work was done with this type early in the century. Apparently, the idea originated in France.

[1] M.S.A.E.—Chief engineer, Outboard Motors Corp., Milwaukee.

[2] Sales manager, Elto division, Outboard Motors Corp., Milwaukee.

Obviously, the engineering obstacles prevented the electric outboard from being a success, just as they stopped the development of steam outfits.

In 1902 the Motogodile Company in France produced a single-cylinder outboard gasoline engine which operated successfully in some instances but did not gain much favor, as most persons possessed too little mechanical knowledge to operate it successfully.

Early American Gasoline-Engine Units

Four years later an American engine builder, seeking a convenient power application for heavy barges and lighters, developed a large, heavy, single-cylinder, four-cycle gasoline-engine marine powerplant complete and self-contained, including underwater housing, propeller, gasoline tank and ignition system. This was designed to be hooked onto a boat very much as a fireman's ladder hooks onto a window-sill. Engineering defects prevented this engine from becoming a success.

The first commercially successful outboard engine was developed in 1909 by Ole Evinrude. It was a single-cylinder two-port two-cycle battery-ignited engine, developing $1\frac{1}{2}$ hp. at about 1000 r.p.m. and weighed 46 lb. In 1921 he developed the first successful light twin-cylinder outboard engine. This was the two-port two-cycle Elto, which developed $2\frac{1}{2}$ hp. at 1400 r.p.m. and weighed 47 lb. In 1922 the Johnson Motor Co. also came out with a light twin-cylinder outboard, weighing 37 lb. and developing 2 hp.

F. T. IRGENS

W. J. WEBB

Since 1921 the growth of the outboard engine in every respect has been rapid. Its production has attained to the dignity of an industry and it has achieved a high degree of public confidence and acceptance.

Development of the Service Outboard

To present a clear picture of the outboard engines, the different sizes and makes of service engine have been averaged, approximately, in Table 1. The racing engines, which are more difficult to tabulate, will be dealt with later.

The smaller engines, such as the type shown in Fig. 1, are used for sport such as fishing and hunting, on dinghies and on small rowboats; the larger ones for big rowboats, runabouts, small cruisers, auxiliaries on sailboats, and some for commercial fishing.

The more important requirements in outboard-engine construction have been: (*a*) power, (*b*) light weight, (*c*) easy starting, (*d*) simplicity of operation, (*e*) simplicity of construction, (*f*) low cost, (*g*) smooth running and (*h*) quiet operation.

The manufacturers' answer to these requirements has been the two-cycle engine, including the single-cylinder and the two and four-cylinder opposed types. These utilize crankcase compression, and lubrication is taken care of by mixing the oil with the fuel. This answer is a compromise as regards other engineering problems and is not at all universally accepted, particularly for the larger sizes, in which fuel and oil consumption is large.

Four-cycle outboard engines have been built in this Country and several are being produced in Europe, but the two-cycle engines predominate in respect both to number and performance. The two-cycle outboard engines were built according to the two-port principle; that is, with a piston-controlled bypass and exhaust port and an automatic intake or mixing valve to the crankcase. This type of engine is still being manufactured and has given a good account of itself for easy starting and for moderate-speed service running.

Next the three-port engine was favored by the manufacturers. In this the intake to the crankcase as well as the exhaust and bypass are controlled by the piston. This construction is the simplest and cheapest possible, and the engine has shown remarkable speed but has a disagreeable carbureter noise. Both the two-port and the three-port engines can be run in either direction, with suitable ignition.

The latest development in outboards is the use of rotary valves to control admission of the charge into the crankcase, as illustrated in Fig. 2. This was brought about by the desire for more power and quiet operation. The rotary valves have been made in two types: the gear-driven barrel-type valve, driven at engine or one-half engine-speed; and valves integral with the crankshaft cheeks, using either the periphery or the cheek side for valve surface. The gear-driven valves are more expensive, absorb more power and are somewhat noisier, but give the designer more latitude in the matter of valve areas.

All of these types are now being manufactured in competition with one another.

Great advances have been made in muffling the exhaust of outboard engines. The two-cycle exhaust, while not great in volume, produces a sharp staccato noise that is annoying when not muffled. From the scientific and experimental angle, the science of building correct mufflers, if it can be called a science, will be materially assisted by recently developed instruments that accurately measure the volume and intensity of sound. One of the most noteworthy efforts in this direction has been

made by the Burgess Laboratories, of Madison, Wis. The Burgess acoustimeter, or noisemeter, as it is called, proves definitely that a street-car at a distance of one city block produces a larger and more intense volume of sound than an unmuffled Class-C outboard engine at an equal distance. A street-excavating machine at a distance of three blocks produced as much measurable sound as a Class-C outboard engine fitted with a stock muffler.

This proves that outboard-engine exhaust noise is no greater than ordinary street noise. The difference is that we are used to and expect street noises, but outboard-engine noises on a lake are unexpected and carry much farther across water surface. Much of the outboard's early unfavorable reputation was occasioned by the exhaust noise, hence the engineering problem of achieving maximum silencing with the minimum loss of power arose at once.

Solving the Muffler Problem

In engines developing the larger horsepowers, such as automobile engines, the margin of developed power for the work to be performed was sufficient to permit a considerable power loss through muffling; but the horsepowers developed by outboard engines are not large at best, and any loss in power through muffling meant a serious reduction in performance. Furthermore, outboard-engine mufflers must of necessity be small and light. Many types were tried. Applications of the Maxim-silencer principle have been worked out with a fair degree of success. However, it seemed that really efficient muffling was difficult to achieve until the underwater exhaust was developed. As is well known, exhaust silencing is achieved through expansion and cooling. The idea of using underwater exhausts is as old as the outboard engine itself, but when used on the slow-speed low-powered engines too much back pressure was developed. With the development of higher boat-speeds, the idea was revived and, with a well-designed system, speeds higher than with wide-open exhaust have been obtained.

In the present-day efficient underwater exhaust, the gases are conveyed through an exhaust manifold and shell down to the lower housing, where they are discharged into a flat, hollow, roughly rectangular plate open at the rear end. This plate is under water when the boat is in motion, and the rush of water over and past the plate tends to form a vacuum within the plate, with the result that the gases are drawn out by suction in addition to being forced out by their own expansion. This reduces back pressure on the cylinders to the minimum, and the exhaust noise is effectually silenced because of proper expansion and cooling, both under water and in the generous spaces provided in the muffler manifolds and shells. It is important that the gas be emitted in a flat, wide stream; the flatter and wider the better, for the greater the area of expanding gas exposed to the cooling water, the more effectual is the suction cooling and silencing.

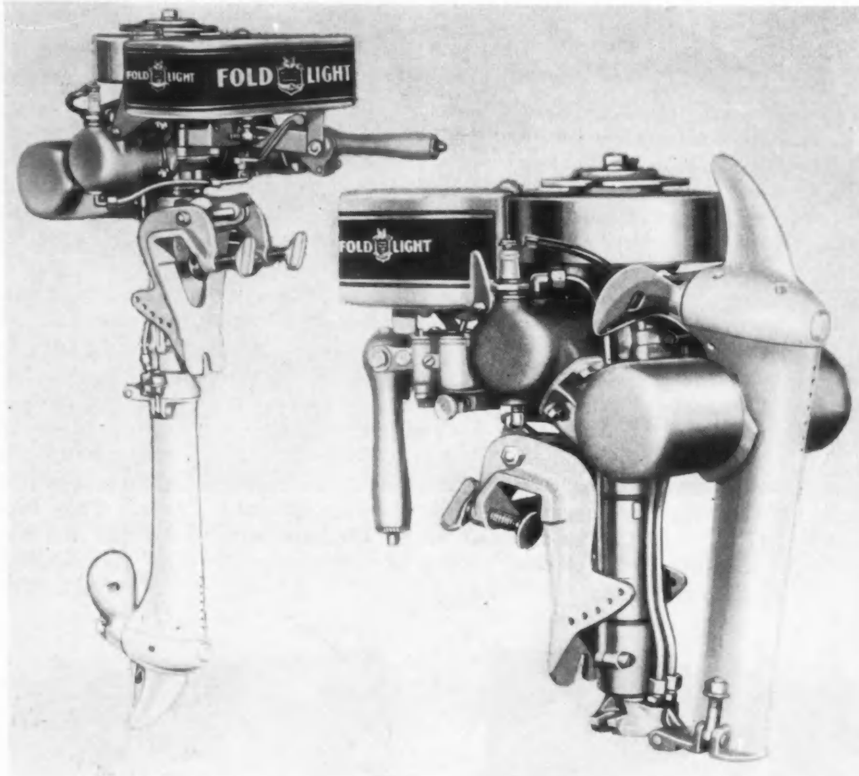


FIG. 1—LIGHT TWO-CYLINDER TWO-CYCLE SERVICE OUTBOARD ENGINE WITH FOLDING LOWER UNIT

In the Left View the Lower Unit, Carrying the Propeller and Cooling System, Is Shown Extended for Driving the Boat. The View at the Right Shows the Engine Folded for Convenient Handling and Transportation. This Outfit Complete Weighs 29 Lb., Develops 2¾ Hp. and Folds to 11½ x 13¾ x 17 In. The Starting Flywheel, Operated with a Pull-Cord for Starting, Is at the Top, Back of the Fuel Tank. Behind and below the Cylinders Is a Pair of Silencers, between Which the Lower Unit Folds up. Cooling Water Enters the Propeller-Shaft Housing through a Series of Holes in the Forward Edge of the Streamlined Housing, Passes up to the Cylinders and Returns down to Outlets in the Propeller Blades Which Act Like a Suction Pump. A High-Tension Magneto Built into the Flywheel Supplies Ignition Current

TABLE 1—CLASSIFICATION OF SERVICE OUTBOARD ENGINES BY APPROXIMATE SIZE AND POWER

	Piston Displacement, Cu. In.	Weight, Lb.	Horsepower
Lightweight Engines	5 to 10	27 to 35	1 to 3
Class A	14	50	6 to 10
Class B	20	75	12 to 15
Class C	30	95	18 to 22
Class D	40	130	25 to 30
Class E	50	125	30 to 35

Considerable experimental work has been done with mufflers that silence according to acoustic principles; that is, a muffler pipe is lined with sound-absorbing material. These acoustic mufflers work out wonderfully while new, but the constant shock of exploding gases breaks down the absorbing material after a few hours. Probably something worthwhile will be developed along this line, however.

With some engines it has been found that some sort

of a muffler is necessary for peak efficiency, for, strange as it may seem, some two-cycle outboards are not as fast nor as powerful when they exhaust straight into the open air from the cylinders as when there is some slight muffling obstruction. This has been shown by numerous experiments. The reason is that, without any muffler, a greater turbulence exists in the combustion-chamber, with the result that part of the fresh charge is blown out before it is fired. The use of some sort of muffler, even though relatively inefficient, assists in scavenging by decreasing combustion-chamber turbulence and thus causing a greater part of the fresh charge to be retained. So it seems that, in some instances, probably because of improper port sizes and deflector shapes, a slight amount of back pressure is necessary for peak performance.

Electric Starters Now Being Fitted

To digress a moment, let us consider one of the greatest outboard-engine developments ever conceived; that is, the electric starter. For several years increasing numbers of boat owners have been asking us to produce an electric-starting outboard engine that would start at the touch of a button just like their automobiles. Obviously, the problem was a difficult one, but we solved it by the use of a motor-generator type of starter, as shown in Fig. 3. This unit is substantially the same type of starter as was used for years on the Dodge, Franklin and other automobiles. Below a speed of 1500 r.p.m. it acts as an electric motor and draws current from a storage battery; above 1500 r.p.m., the process is reversed and the unit acts as a generator, recharging the battery and furnishing ignition. Both 6 and 12-volt units are used.

Two general sources of current for ignition are used in outboard engines: the battery and the magneto. The magneto is of the standard built-in flywheel type and needs no explanation. Battery ignition is of either the open-circuit type, as exemplified by the Atwater Kent Unisparker, or the conventional closed-circuit type. Magneto ignition has until this year been the most satisfactory for racing and is still used on racing engines. The closed-circuit battery ignition, however, has rapidly taken first place, as it furnishes a hot, fat spark at all speeds, particularly when starting, and the spark is instantaneous, of even intensity at high speeds, and can be made to occur exactly when and where wanted.

A strong vogue exists for endurance contests of all kinds. The endurance fever hit the outboard-boat enthusiasts in 1930, with the result that some excellent records were established. At present a Lockwood engine holds the record, with an official non-stop run of 552 hr. This engine could have continued but was stopped purposely by the drivers. An Evinrude engine made the second highest record, of 483 hr., and an Elto was third, with 415 hr. These records speak volumes for the dependability and durability of the modern outboard engine. Only the records of airplane engines exceed those of the outboard engine.

Impetus Given by Racing

Spectacular outboard racing has done the most to attract public attention to the outboard engine. (See frontispiece.) In this field, as in others, the racing engineer has achieved the improvements that are responsible for the greatly improved product now made

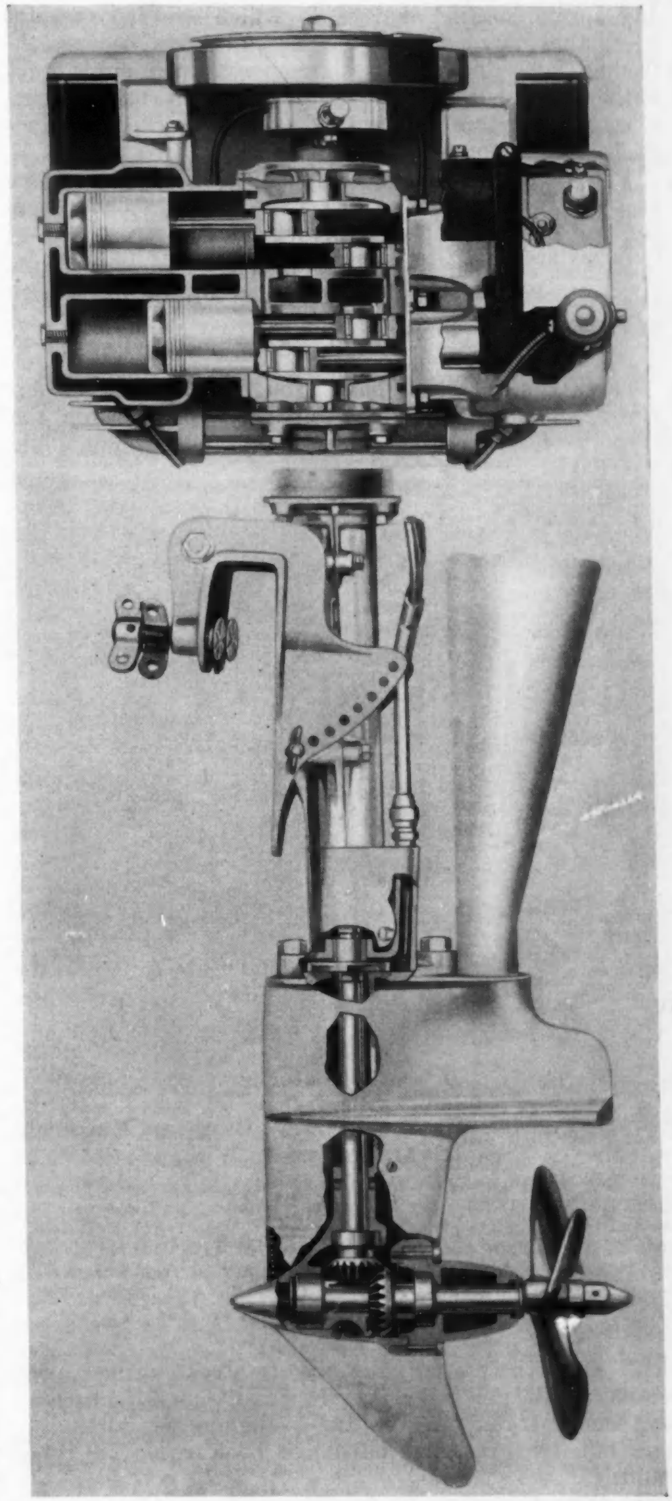


FIG. 2—LARGEST SERVICE OUTBOARD ENGINE BUILT—THE ELTO QUAD

This Is a Four-Cylinder Two-Cycle Engine of 50-Cu. In. Piston Displacement and Develops 35 Brake Horsepower. As Shown in the Partly Sectioned Power-Head, It Has Crankshaft Rotary Valves Located in the Crankcase between the Two Banks of Cylinders. A Flat Underwater Exhaust Outlet Is Formed in the Streamlined Lower Housing above the Propeller, and Cooling Water Is Admitted through an Aperture in the Front Edge of the Lower Housing just back of the Propeller Shaft, whence It Passes through a Centrifugal Pump to the Cylinder Jackets

available for service use. We are, however, now building special racing engines in which are incorporated ideas that may not have commercial value, because the racing rules necessitate horsepower per cubic inch rather than horespower per pound. The basic racing rules used in this Country have had a marked influence on the development of the modern outboard engine.

The racing rules require the use of stock engines as built and specified by the manufacturers and forbid the use of superchargers. The engines are classified by sizes according to cubic displacement as follows:

Class	A	B	C	D	E	F	G
Displacement, up to, cu. in.	14	20	30	40	50	60	80

These classifications have brought about higher engine-speeds and somewhat intricate designs, for the purpose of bettering the horsepower output per cubic inch. Since the racing rules specify stock engines, and because the larger and more progressive manufacturers have concentrated on the two-cycle engine, virtually none but two-cycle engines have been raced in this Country.

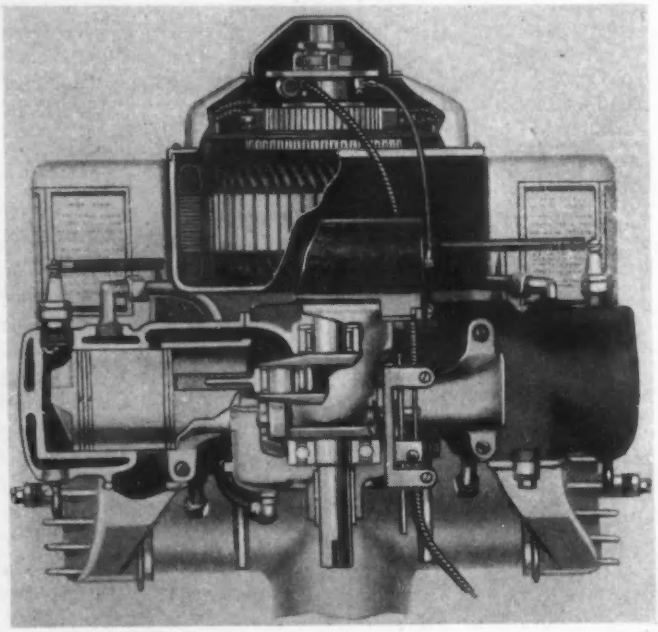


FIG. 3—ELECTRIC-STARTING POWER HEAD OF EVINRUDE SPEEDITWIN

This Has a Motor-Generator Starter Substantially of Automobile Type That Is Located above the Cylinders and Serves also as a Flywheel. The Engine Is of the Three-Port, Valveless, Twin-Cylinder Type and Develops 22 Hp. at 4500 R.P.M. When the Engine Speed Reaches 1500 R.P.M., the Starter Acts as a Generator to Charge the Battery. Complete with Lower Propeller-Unit, the Engine Weighs 124 Lb.

The three basic factors for increased speed in racing, as far as the powerplant is concerned, are:

(1) Increased horsepower per cubic inch
(2) Light weight
(3) The most efficient utilization of the power.

Methods of Increasing Horsepower

The increase in horsepower has been obtained by increasing the crankshaft speed. At present we are running engines between 6000 and 7000 r.p.m by raising the compression ratios as high as 9:1 and 10:1; by increasing the volumetric efficiency by port timing, rotary valves and larger gas passages, and by experimenting with crankcase pressures, piston-deflector shapes and combustion-chamber shapes; and by improving the mechanical efficiency through improved balance and more liberal use of antifriction bearings.

The high compression-ratios can be used without the addition of antiknock ingredients because of the large percentage of burned gases retained in the combustion-chamber. Thorough scavenging is difficult with the simple two-cycle engines, mainly owing to the low volumetric efficiency of the crankcase. If the crankcase volume is made smaller so as to increase this efficiency, too high a crankcase pressure is obtained for smooth scavenging, as too much turbulence during the scavenging period is set up. In one of the latest racing engines the crankcase volume is made as small as practicable, to obtain high crankcase-suction, but the peak crankcase pressure is kept moderate by connecting the crankcase to a receiver during crankcase compression.

Roller-bearings are used almost universally on the crankpin end of the connecting-rod. The crankshaft and rods are case-hardened chromium-nickel steel. Ball-bearings are used on the crankcase journal and also on the propeller driveshaft. Lynite pistons are used entirely. Some trouble has been experienced from burning out of the piston-heads, and much research work is being done on this problem. The high deflector exposes a large area to the burning gases, and, when the fact is considered that the mixture in the two-cycle engine burns once for every revolution, one realizes the tremendous amount of heat that has to be conducted away. Moreover, the heat transfer through the piston-rings is hampered by the fact that a large percentage of the cooled cylinder-wall area is taken up by ports and ribs.

The horsepower has been increased from about 1 hp. per 5 to 6 cu. in. to better than 1 hp. per 1 cu. in.

The engine called the Speedy Bee represents one of the highest developments in outboard two-cycle design, having a displacement of 19.93 cu. in. This shows a power development of $22\frac{1}{2}$ hp. at 6600 r.p.m., or more than 1.10 hp. per cu. in. of piston displacement, with a brake mean effective pressure of approximately 68 lb.

How Light Weight Is Attained

The light weight of the outboard engine is secured mainly by simplicity of design and the extensive use of light alloys. Magnesium has not been used much because of its high price and its susceptibility to corrosion when used in and around salt water, but aluminums are widely used.

To achieve lighter weight, crankcases, drive-housing sleeves, underwater housings, engine brackets, gasoline tanks, carbureters and like parts are made of aluminum alloys. Cylinders are made of gray iron, while shafts, gears, connecting-rods and other parts that are heavily stressed are made of alloy steels.

In some instances detachable lynite cylinder-heads are used, but weight saving is not the object in this case. The reasons are to achieve greater rapidity of heat conduction away from the combustion-chamber and particularly the spark-plug, which in this case is set almost in the center of the top of the combustion-chamber, and to obtain more uniform expansion of the cylinder barrel and a more efficient combustion-chamber space. The best cylinder-head, from a combustion standpoint, may, however, not be the best from a scavenging standpoint. As the use of a detachable cylin-

der-head complicates manufacturing and increases costs, it is justifiable only in view of the better racing results to be obtained from the use of such material. With the single exception of racing, a complete cast-iron cylinder is more satisfactory.

Prior to 1928, outboard pistons were made of gray iron and the connecting-rods of phosphor-bronze. The advent of higher engine-speeds and the necessity for greater power development brought the demand for lighter reciprocating parts, which in turn resolved itself into lynite pistons and steel connecting-rods. Gray iron is a better piston material than lynite, from a service standpoint.

How Power Is Used More Efficiently

The most efficient utilization of power results from a combination of mechanical efficiency and streamline efficiency in the water. The plain bevel-gear transmission is universally used between the vertical driveshaft and the horizontal propeller-shaft. The gear and bearing sizes are very small compared with the power transmitted and are possible only because of the effective cooling and greasing of the gear-housing. The gear ratio depends on the following factors: speed of the boat, pitch of the propeller, and speed of the engine at peak horsepower. The diameter of the propeller is always held to the minimum to keep the propeller-tip speed as low as possible, the limiting factors being slippage and cavitation. Slippage on a well-designed unit is between 10 and 15 per cent. The ratio of pitch to diameter on the majority of propellers now used is between 1.5 and 1.75 to 1. The most successful propeller design seems to be one having narrow, thin tips and relatively wider blades toward the hub to give sufficient blade surface. When the propeller pitch is selected, the propeller speed is determined, and a gear ratio is chosen that will let the engine turn over at its peak speed.

With boat speeds now above 50 m.p.h., streamlining of the underwater parts is of great importance from the standpoint both of eliminating the drag and preventing cavitation. Correct streamlining is of utmost importance for another reason. If the gear-housing were not properly streamlined, it would be impossible for any driver to prevent capsizing when speeds of 40 to 50 m.p.h. were attained. The forward edge of the housing must break the water with a minimum of disturbance. From this point backward, the design must be such that the water cleaves to the housing instead of flying away, so that the split stream of water meets or almost meets again at the rear edge and in front of the propeller.

Both tractor and pusher-type drives are used, and, judging from racing results, it is a matter of personal opinion which is the better. The tractor screw works in more solid water, but the gear-housing has a higher drag by having to go through the propeller slipstream.

Remarkable Progress Made in 10 Years

While we fully appreciate that new developments are yet to come, it is interesting to look back and compare the uptodate racing outboard engine with some of the earlier engines, principally because the basic layout and the types of engine have been adhered to. The engines are still suspended as they were long ago; we are still using the simple two-cycle engine, and the power transmission is identical in principle.

In 1919 an engine speed of 800 to 1000 r.p.m. was normal; in 1922 the speed went up to 2000 to 2300 r.p.m.; in 1927, to 3500; and now we are running engines at 6500 r.p.m. The propeller speeds have, of course, also increased.

In 1919 the propeller speeds were about 800, and today we are running the propellers up to 3500 to 3700 r.p.m. To show the possibility of radical changes in our conception of the most efficient propeller drives, it is interesting to note the high propeller-speed and slippage which Major Segrave was using. From figures it is calculated that the propeller of his speed boat was turning at a rate of 12,500 r.p.m., giving a slippage of 50 per cent.

A graphic picture of the progress of outboard engineering can be gained from a brief survey of outboard-racing achievements in the last five years. Until 1925 the outboard boat was regarded merely as a dependable means of water travel, and boat speeds were comparatively low, being less than 10 m.p.h. The year 1925 saw the beginning of the development of high-speed racing outboards. In the summer of that year a twin-cylinder Johnson engine weighing 90 lb. achieved the unbelievable speed of 15.98 m.p.h. In 1926 another Johnson engine of the same weight, developing 6 hp., performed the impossible and made 22 m.p.h., and in the same year a Lockwood engine of one-half the piston displacement, developing between 4 and 5 hp., made 21 m.p.h. The following year a Class-C Johnson engine, weighing 100 lb. and developing about 11 hp., made 32 m.p.h. Also in 1927, a Class-B Lockwood, of one-half the weight, displacement and power, made 23 m.p.h.

Remarkable developments were made in 1928, when a new racing class was introduced—Class A, for engines under 14-cu. in. piston displacement. In this class the Lockwood Ace, developing 7 hp. and weighing 55 lb., set a record of 27 m.p.h. Development of Class B, for engines between 14 and 20-cu. in. displacement, was equally sensational. The Lockwood Chief, a Class-B engine developing 11 hp. and weighing 75 lb., achieved 33 m.p.h. The same year saw phenomenal development in Class C for 20 to 30-cu. in. engines in which the Evinrude Speeditwin, developing 16 hp. and weighing 95 lb., swept the field with a speed of 38 m.p.h.

In the same year the Elto Quad, the first four-cylinder outboard engine, was introduced. This was a Class-D engine of 30 to 40-cu. in. displacement, weighing 95 lb., and achieved the world's record speed of 41.749 m.p.h.

Even greater developments occurred in 1929, when records in all classes were raised from 1 to 8 m.p.h. The season's peak speed of 49.47 m.p.h. was made by a four-cylinder Johnson Class-D engine weighing 130 lb.

The year 1930 has seen still greater advances in engineering and power development. Recently an Elto Four-Sixty, weighing 116 lb. and developing nearly 45 hp., set a new official record of 50.934 m.p.h. (See frontispiece.) Everything considered, this is a remarkable speed to be achieved with a powerplant that the average man can lift without trouble. Class-A development has also shown excellent progress this year. Caille has developed a fine little engine developing 13 hp. which recently set a record of 31 m.p.h.

From a superficial glance at these figures it may seem that the larger, more powerful engines are not producing the speeds they should, but such is not the case. As is well known, doubling the power does not double the speed in any vehicle. In the case of the outboard

boat, water resistance increases as the cube of the speed; so, after all, the larger engines are keeping up with development progress.

Thus, in the span of 10 years, we have a picture of phenomenal development, as follows:

	1920	1930
Ratio of Power to Piston Displacement	1 hp. to 6-7 cu. in.	1 hp. to 0.9 cu. in.
Ratio of Power to Weight of Engine, Including Drive-Housing	1 hp. to 20 lb.	1 hp. to 2.25 lb.
Engine Speed	1,000 r.p.m.	6,000 to 7,000 r.p.m.
Speed of Boat	7 m.p.h.	51 m.p.h.

Drivers and Boat Builders Have Helped

Some of these figures look great indeed, but it must be remembered that one change brings about another, and, as engine builders, we have to give much credit to the boat builders and racing drivers who have worked hand in hand with us. Racing drivers have, in effect, become an auxiliary corps of engineers. Most of them are youthful enthusiasts, possessed of considerable mechanical ingenuity. They spend many hours each week during the summer in smoothing, polishing and "souping" their engines so as to get the last possible inch of boat speed out of them. There are several thousand drivers, and among such a number it is natural that some of them will hit upon very good new ideas. All of these serve to increase outboard-engine efficiency.

Boat builders have shown as phenomenal progress as have the outboard-engine manufacturers. Prior to 1925, the fastest outboard boat was thought to be the long, slim craft which would slice through the water, and it was the fastest type for the power then available. Then came the V-bottom hydroplane, a boat that rode flat on the water instead of cutting through it. Next came the step-plane, which was simply a V-bottom hydroplane with a transverse step cut in the bottom, designed to ride at full speed on two points in the bottom. Further refinements in the outboard step-plane have been made, until now internationally known big-speed-boat designers are taking chapters from the experience of outboard-boat designers.

THE DISCUSSION

W. F. KRENZKE[3]:—Is the 10:1 compression-ratio used in racing or regular production engines, and how high is the crankcase compression?

F. T. IRGENS:—The 10:1 ratio is used in the racing engines. The regular production engine has a compression ratio of 5:1 or 6:1. The crankcase compression is from 4 to 8 lb. per sq. in. in service engines.

MR. KRENZKE:—Does increase in crankcase compression increase the cylinder compression?

MR. IRGENS:—No, the two are independent.

ROBERT I. DICK[4]:—What is the reason for the practically universal use of the two-cycle principle in outboard-engine design?

MR. IRGENS:—The reason is simplicity. In dealing with the general public, which is not mechanically inclined, the simplest engine is the best. Oil can be mixed with the fuel and there is no oil supply to splash around. Such an engine is simple and light and has the maximum power per pound.

MR. KRENZKE:—Is the oil mixed with the liquid fuel or is it taken in through the intake manifold?

MR. IRGENS:—It is mixed with the liquid gasoline. One quart of oil is used to 1 gal. of gasoline for racing, with a smaller quantity of oil for general service.

QUESTION:—What temperature does the oil attain in racing engines?

MR. IRGENS:—The oil is consumed along with the gasoline in which it has been dissolved. Some racing engines have a separate oil-tank and a pump that sends oil to the bearings, whence the oil escapes and is wasted.

MR. DICK:—Does the crankshaft limit the speed to the 6500 or 7000 r.p.m., or is it the rate of piston travel?

MR. IRGENS:—The piston speed is relatively slow in the short-stroke engine used. The volumetric efficiency is the limiting factor.

EARL L. KULLMAN[5]:—What is the fuel consumption in pounds per brake-horsepower-hour?

MR. IRGENS:—We prefer not to discuss that point in great detail, as the consumption is rather high; however, in the smaller-size engines and in racing the cost of fuel is a relatively small factor. For general service, about 1 to 1¼ lb. of fuel is required per brake-horsepower-hour.

MR. KRENZKE:—Is the figure of 1 to 1¼ lb. per brake-horsepower-hour based on the consumption of gasoline only?

MR. IRGENS:—Yes.

QUESTION:—What is the bore-to-stroke ratio?

MR. IRGENS:—It is not fixed but the industry generally uses a piston of 2⅜-in. diameter with a 2¼-in. stroke and a piston of 2¾-in. diameter with a 2½-in. stroke.

QUESTION:—What is the connecting-rod length as compared with the stroke?

MR. IRGENS:—The rod is made as short as other factors of the design make possible.

CHESTER S. RICKER[6]:—In getting increased power, why are additional cylinders used instead of increasing the cylinder size? Is it a question of port area per cylinder?

MR. IRGENS:—The burning of piston-heads is the problem. The danger of burning limits the piston diameter, as a large piston cannot be sufficiently cooled. Increasing the length of the stroke permits increasing the port area.

QUESTION:—What is the piston-ring wall-pressure?

MR. IRGENS:—It has to be low to enable the ring to pass the ports in the cylinder. With a 2⅜-in.-diameter ring it is from 4 to 5 lb. Rings ⅛ in. wide are used.

M. P. C. CHRISTENSEN[7]:—What is the effect of using a mixture of alcohol and benzol?

MR. IRGENS:—We have had little experience with such mixtures but understand that some racing drivers use them.

(*Concluded on p.* 52)

[3] M.S.A.E.—Chief engineer, Jacobsen Mfg. Co., Racine, Wis.

[4] Assistant chief engineer, Wisconsin Motor Co., Milwaukee.

[5] Jun. S.A.E.—Assistant superintendent, Wadhams Oil Co., Milwaukee.

[6] M.S.A.E.—President, Day-Nite, Inc., Waukesha, Wis.

[7] Service manager, Jacobson Mfg. Co., Racine, Wis.

Machining Aluminum and Its Alloys

Discussion of R. L. Templin's Production Meeting Paper[1]

TOOL FORMS for machining aluminum were described in detail and illustrated in the paper. The chief difference between these and tools suitable for steel are that the tools for aluminum should have comparatively large rake and clearance angles for best results, leaving a relatively thin cutting-edge. Forms of lathe and shaper tools and inserted-tooth milling-cutters which can be used were shown.

Discussers raised the question of the actual acceptance of recommended tools and cutting speeds by individual machinists, and the author said that machinists sometimes ignore correct specifications.

Tungsten-carbide tools only are said to be practical for machining the new aluminum alloys that have been developed for the low coefficient of thermal expansion. These tools need to be of the same form as is recommended for steel tools.

Information on methods and tools for the tapping and external threading of aluminum were given in answer to a request.

JOHN YOUNGER[2]:—Is it not true that many shops are using tools that are improperly ground for machining aluminum, because they do not know the correct methods? If so, what can be done about it?

R. L. TEMPLIN:—Conditions are as Professor Younger suggests, and we are called upon to investigate numerous difficulties in machining aluminum alloys. Frequently the purchasing agent says, "Oh, yes, we have all your literature on machining aluminum and are grinding our tools as you recommend, but still they do not work well." In most of these cases—I do not know of a single exception—we find when we get to the man who actually does the work that he "does not believe in that stuff" and follows his own ideas. Such conditions do not frequently arise in the automotive industry, but we do find them in other commercial fields.

Alloys of aluminum that contain an appreciable amount of silicon are the toughest ones to machine; at the same time, they are very desirable for certain uses—notably, for engine pistons—because of their low coefficient of thermal expansion. It may not be generally known, but we are now making forged pistons of the silicon alloy for radial-cylinder aircraft-engines. The only satisfactory way that we have found to machine these pistons is with cemented-tungsten-carbide tools, ground as nearly as possible to the shape indicated in the paper. We obtain very satisfactory results with these tools. However, I wish to emphasize the fact that merely selecting a tungsten-carbide tool is not sufficient; it must be ground to the correct cutting and clearance angles to function so as to give the best results.

CHAIRMAN J. A. BOHANNON[3]:—I appreciate the point of Mr. Younger's question because lately our organization has been considerably interested in machining aluminum and we have found that many individuals are not posted on machining practice for aluminum and not responsive to the idea of using aluminum because of machining difficulties.

Threading, Tapping and Reaming Recommendations

N. P. PETERSON[4]:—Has Mr. Templin any advice to offer in regard to threading, tapping and reaming aluminum?

MR. TEMPLIN:—We have had occasion to do considerable threading and tapping in screw-machine production. One of the best methods for tapping is to use a spiral-fluted tap, preferably of high-speed steel, ground all over. Taps that are furnished on the open market are deficient in clearance at the back of the lands; they should be ground with more clearance so that they will back out of the work freely. Otherwise, they tend to drag and result in a poor finish on the threads. I have even made taps that work well from old high-carbon twist-drills.

Threading machines of certain makes can be well adapted for cutting external threads on aluminum by grinding additional top rake on the cutting edges and additional side rake in some cases. We have used this scheme with good results for threading quantities of aluminum conduit. Reamers most suitable for use on aluminum are of the spiral-fluted type.

Pure lard-oil we consider to be the best lubricant, but its cost probably is prohibitive for general work, so a mixture of kerosene and lard-oil can be used if fire rules permit it. Otherwise, we recommend soluble cutting-oil, mixing it a little thicker than it would be normally used for steel. We use 15 parts of water to one part of soluble oil, while the ordinary recommendation is about 20 to 1.

A. H. LYON[5]:—I should like to inquire about the speed and rate of feed that are practicable with the milling cutter shown in Fig. 3.

MR. TEMPLIN:—Definite directions as to speed and feed are difficult to make because they are interrelated with other machining conditions. Data given in the paper were for the cutter shown in Fig. 4. Under certain conditions we can improve on those speeds and feeds by using the cutter shown in Fig. 3, in which provision is made for disposing of the chips.

[1] The paper was printed in the November, 1930, issue of the S.A.E. Journal, beginning on p. 548. The author is chief engineer of tests, Aluminum Co. of America, New Kensington, Pa.

[2] M.S.A.E.—Editor, *Automotive Abstracts;* Professor of industrial engineering, Ohio State University, Columbus.

[3] President, Peerless Motor Car Corp., Cleveland.

[4] M.S.A.E.—Works manager, Canadian Acme Screw & Gear, Ltd., Toronto, Ontario.

[5] M.S.A.E.—Chief engineer, Ingersoll Milling Machine Co., Rockford, Ill.

Lead-Base Lubricants and Their Use

Cleveland Section Paper

By James A. Edwards[1]

INCREASE in the horsepower and driving speeds of motor-vehicles has resulted in greater gear-tooth pressure in the transmissions and rear axles and caused a movement toward the use of gear lubricants capable of providing an oil film that will withstand the high tooth-pressures and prevent scuffing of the gear teeth.

The author states herein that lead-soap-base lubricants provide such an oil film and that therefore a more fluid lubricant can be used, thus reducing gear wear, promoting ease of gearshifting and freedom from the tendency to "channel" and decreasing power loss.

Excessive gear wear and noises still prevail, although constant improvement has been made in gear design, metallurgy, accuracy of machining and in heat-treating. Much of the trouble can be traced to the use of lubricants of poor quality or that are unsuitable for the operating conditions. Conventional gear-lubricants apparently lack the quality of oiliness which chiefly distinguishes between good and poor lubricants for conditions of heavy tooth-loads and high temperature.

Rather wide differences in lead-base lubricants and in specifications as set up for them by manufacturers of automotive equipment are discussed. Laboratory tests of physical and chemical properties called for b yspecifications are said to serve only to determine uniformity, while service tests to ascertain actual lubricating value require long and costly procedure. Therefore, oil-film breakdown-test machines specially built for the purpose are commended as a means for quickly and reliably testing the service value of lubricants.

Many investigations of the qualities of other compounds may be under way, but, until they are completed and more data are obtained, the lead-base lubricants seem to be the best type known for gears.

The tendency of undesirable ingredients in some lubricants of this type to increase the rate of wear on either the gears or the bearings is not denied, but the author points out that abrasive material resulting from scuffing of gear teeth when a lubricant is used that cannot maintain an adequate oil-film will be more detrimental to the entire unit than even a poorly manufactured compound containing lead oxide or free sulphur that can prevent scuffing.

In conclusion, a suggestion is made that the Society undertake to establish standard specifications for satisfactory lubricants of the lead-base type.

JAMES A. EDWARDS

LEAD-BASE lubricants, while comparatively new insofar as the public is concerned, have been known and recognized for a number of years, mostly under trade names covering compounds, little if any mention ever being made regarding their composition.

Application of lead-base lubricants has been confined principally to the lubrication of enclosed gear mechanisms, such as transmissions, differentials, steering-gears and some industrial gear mechanisms, generally in the form of fluid lubricants, although such lead-base lubricants have been used rather extensively for open gears, generally in a plastic form requiring heating of the lubricant in order to make application.

Increased horsepower and higher driving-speeds, which have resulted in increased tooth-pressures, have caused a movement in the automotive field in recent years toward the use of gear lubricants capable of withstanding higher tooth-pressures so as to prevent scuffing of the gear teeth. Lead-base lubricants have been found to form a more permanent oil-film under conditions of higher pressures and temperatures irrespective of viscosity, for which reason more fluid lubricants may be used to advantage as a means of promoting easy gearshifting and freedom from tendency to channel while also affording lower power-losses, to which may be added the all-important factor of reducing gear wear and failure. Other uses than for gear units for which these lubricants may be employed are as yet little understood, and a detailed study covering further applications of this type of lubricant seems to offer many possibilities.

Examinations of the physical properties of lead-base gear lubricants show little difference from conventional straight-hydrocarbon gear lubricants, while chemical analyses show such lubricants to contain variable percentages of lead soap.

Gear Lubrication Needs More Study

The problem of good lubrication of such parts as transmissions and rear axles has received considerable attention, in keeping with the modern trend of auto-

[1] M.S.A.E.—President, Jesco Lubricants Co., North Kansas City, Mo.

motive engineering. Still there seems to be much room for improvement along these lines. Gear design, accurate machining, careful heat-treating and metallurgical consideration have received marked attention and have shown constant improvement, yet casual observation readily indicates that considerable trouble prevails as to excessive wear and gear noises in both transmissions and rear axles. Much of this can be traced to the use of a lubricant of poor quality or one that is unsuitable for the operating conditions.

Lubrication of gear units, in many cases, has not received sufficient consideration as a means of prolonging the service value of transmissions and rear axles. Exceptions to this statement may be found in the lubrication of hypoid gears, considerable research work having been carried on in this field through necessity, since it was found that conventional gear lubricants, such as soda-soap greases, viscous hydrocarbon oils and some fatty oils, while possessing satisfactory physical properties, apparently lack sufficient of that characteristic called "oiliness" which, to a major degree, distinguishes between good and poor lubricants, particularly under conditions of heavy loads and high temperatures.

Lead-base lubricants composed of lead soap intimately mixed with hydrocarbon oil supply a type of lubricant that is capable of maintaining a permanent oil-film under the condition of high pressures. This has not been possible to do with ordinary gear lubricants. Unfortunately, no satisfactory explanation for this commendable characteristic of lead-base lubricants can be given at this time, since any explanation would involve a detailed study of the film-forming tendency which is beyond the scope of this paper.

Differences in Lead-Base-Lubricant Specifications

Analyses of lead-base lubricants now available show rather wide differences, as might be expected because of differences in

(1) Raw material used in manufacture
(2) Method of manufacture: (*a*) type of equipment employed, (*b*) temperature and time of cooking, and (*c*) rate of mixing
(3) Specifications followed during manufacture.

The specifications of several manufacturers of automotive products, as given in Table 1, indicate the rather wide difference of opinions regarding such lubricants. Differences concerning such products also exist among the numerous lubricant manufacturers.

An additional test covering the tendency of lead-base lubricants to foam is made by stirring approximately 100 cc. of the oil at 90 deg. fahr. with a Dover egg-beater for 2 min. at a normal rate of speed by hand, during which time the lubricant should not increase in volume more than 25 per cent and should be well settled out in 30 min. and all out in 40 min. This test is useful as a means of determining the likelihood for a marked increase in volume in service, causing leakage around axles and propeller-shafts.

One test that is perhaps equally important with all tests conducted on lubricants of this class is that of determining the percentage of free lead present, since experience has proved that the presence of free lead may often act as a mild lapping agent, particularly on ball and roller-bearings, and, as free lead can be eliminated during manufacture, its presence should be avoided.

Laboratory tests such as those indicated, covering the physical and chemical properties of lubricants, seldom do more, after definite specifications have been drawn, than serve as a useful means of determining uniformity. This is unquestionably true in the case of lead-base lubricants; hence some form of service test for the determination of actual lubricating values is necessary.

Service tests usually require a prolonged and costly procedure, for which reason efforts should be made to standardize upon some form of lubricant breakdown-test machine, such as those developed by the Timken Roller Bearing Co. and the General Motors Corp. That these machines hold promise of a comparatively quick and reliable means of testing the service value of lubricants is best made evident by the excellent results obtained by E. G. Boden[2] and H. C. Mougey[3] with their respective test equipment with which breakdown tests of lubricants can be economically and quickly made under pressures up to 20,000 lb. per sq. in. and higher.

The bearing surfaces used in such tests have, in most cases, represented commercial practice as to finish of the surface. This is of considerable significance, as it makes possible reasonable comparison between such tests and results that will be obtained in actual service with completed gear-units. The breakdown tests in these machines reveal

(1) The point of film rupture of the lubricant, as indicated by abrasion or scuffing of the bearing surfaces
(2) The coefficient of friction
(3) Temperature increase.

TABLE 1—SPECIFICATIONS OF THREE MANUFACTURERS OF AUTOMOTIVE PRODUCTS FOR LEAD-SOAP LUBRICANTS

	A	*B*	*C*
Specific Gravity	1.000	Not given	Not given
Flash, deg. fahr.	Minimum, 320	Not given	Not given
Fire, deg. fahr.	Minimum, 360	Not given	Not given
Viscosity, Saybolt sec. at 211 deg. fahr	95 to 105	90	90 to 100
Pour-Point, A.S.T.M., deg. fahr.	Not given	0	Maximum, 15
Channel Test, deg. fahr.	Maximum, 5	Not given	Not given
Lead Soap, per cent	Not given	Minimum, 12	Not given
Lead Reduced to Free Lead, per cent	5 to 6	Not given	3 to 4
Free Lead, per cent	Not given	Not given	None
Free Oleic Acid, per cent	Maximum, 0.50	Not given	Not given
Free Fat by Weight, per cent	Not given	Not given	Maximum, 2
Total Fat by Weight, per cent	Not given	Not given	9 to 12
Sulphur in Mineral Oil, per cent	Not given	Not given	Maximum, 1
Sulphur Added, per cent	Not given	Minimum, 2.5	Not given
Corrosion	Not given	Bad[a]	None[b]
Color	Jet Black	Not given	Not given
Odor	Inoffensive	Not given	Pine Tar

[a] 10 sec. immersion at 310 deg. fahr., copper strip.
[b] 24 hr. immersion at 70 to 80 deg. fahr., copper strip.

[2] M.S.A.E.—Experimental engineer, Timken Roller Bearing Co., Canton, Ohio.
[3] M.S.A.E.—Chief chemist, assistant technical director, General Motors Corp. Research Laboratories, Detroit.

The manufacture of lead-base lubricants consists, first, of chemically combining suitable fatty oils with lead oxide or litharge, after which the resultant lead soap may be added in any desired percentage to a refined hydrocarbon oil, care being taken that the constituents are intimately mixed so as to produce a smooth, homogeneous product.

All ingredients used in the making of such lubricants should be under laboratory control, to assure uniformity from batch to batch. Also, the manufacturing equipment should, to the fullest extent, be automatic in operation and thermostatically controlled as to temperature. When every precaution has been taken with regard to constituents and equipment, it is still imperative, if satisfactory results are to be attained, that an experienced personnel be employed.

Lead-Base Lubricants Now Seem Best

I am conscious that perhaps, because comparatively few data on this subject have been made public, many investigations are under way covering compounds other than lead-base lubricants, several of which are known, such as aluminum-stearate greases and sulphurized oils. Such compounds may offer satisfactory service at reduced cost, owing to cheaper constituents and lower manufacturing costs. For the present, however, until further investigations are completed and data obtained, properly manufactured lead-base lubricants seem to offer the best type of gear lubricant known. Such lubricants may be characterized by

(1) Ability to withstand high unit-pressures without abrasion or scuffing of gears
(2) Low cold-test, permitting ease of gearshifting and freedom from tendency to channel
(3) Lower coefficient of friction under high pressure
(4) Quiet and smooth operation.

I am fully aware of the objections offered by bearing manufacturers with regard to those lubricants which, owing to undesirable ingredients, have shown a higher rate of wear than that encountered with refined suitable hydrocarbon oils. It is not my intention to offer any apology for lead-base lubricants or other compounds that increase the rate of wear on either bearings or gears, except to point out that, under conditions of operation where the lubricant employed does not maintain an adequate oil film and scuffing of the gears results, it is natural to expect that the presence of such abrasive material as is produced by the scuffing of the gear teeth will surely act as a detriment to the entire unit to a much greater degree than even a poorly manufactured compound capable of preventing such scuffing, although it may contain such mild abrasives as lead oxide or free sulphur.

Our own experience has been that the presence of free lead or free sulphur can be avoided in manufacture. If this is done, little likelihood exists of any abrasive material being present, and consequently we should not anticipate other than normal wear. We have operated continuously for the last year several cars employing hypoid gears. One of these, which has been driven a total of 27,000 miles in 11 months with a single filling of the differential and with no lubricant added during that time, has, upon examination, shown no need for any adjustment of either the bearings or the ring gear and pinion.

In view of the fact that manufacturers of automotive equipment are not in general agreement relative to lead-base lubricants, although their problems in this respect lie virtually parallel, I suggest that the appropriate machinery of the Society be put in motion to arrive at specifications which will enable the lubricant manufacturers to furnish satisfactory lubricants of this type in as few grades as possible, so that the ultimate users may have available a source of supply upon which they can rely.

Development of the Outboard Engine

(*Concluded from p.* 48)

MR. KRENZKE:—Where are antifriction bearings commonly used?

MR. IRGENS:—At virtually every point, except that main bearings are usually plain or a combination of plain and antifriction type so as to hold the crankcase compression.

HENRY L. DEBBINK[8]:—Are roller-bearings used at the big end of the connecting-rod?

MR. IRGENS:—Yes, for racing.

MR. RICKER:—Is the needle-type bearing used?

MR. IRGENS:—Not as yet.

MR. RICKER:—Are antifriction crankpin bearings used to get faster speed or for dimensional reasons?

MR. IRGENS:—They are used for both reasons. They give good balance because of the shorter crankpins.

QUESTION:—How do you lubricate the upper main bearings?

MR. IRGENS:—Crankcase compression forces the oil into those bearings.

WESLEY B. PUSEY[9]:—Are straight bevel gears used in the propeller-shaft drive in preference to spiral bevels?

MR. IRGENS:—Yes, because of difficulty in closely adjusting those gears.

QUESTION:—What precautions are taken to prevent electrolysis in salt water?

MR. IRGENS:—The use of as few different alloys as possible.

ROBERT W. WILSON[10]:—Do you use special alloys or treat the alloys to prevent electrolysis?

MR. IRGENS:—We use special alloys and heat-treat them for strength. Processes for treating alloys against corrosion are being tried but are not yet used in production.

QUESTION:—Have you used nitralloy in the crankshaft or the piston-pins?

MR. IRGENS:—For samples only.

QUESTION:—Are the fastest engines of the three-port type?

MR. IRGENS:—No, the rotary-valve type is fastest, with the three-port type a close second.

QUESTION:—Why are no three-cylinder two-cycle engines used?

MR. IRGENS:—Because separate crankcases would be required, which would spread the cylinders too much.

[8] M.S.A.E.—Superintendent, gasoline vehicles, Milwaukee Electric Railway & Light Co., Wauwatosa, Wis.

[9] M.S.A.E.—Sales engineer, SKF Industries, Inc., Milwaukee.

[10] M.S.A.E.—Sales engineer, Perfex Corp., Milwaukee.

Observations on the Testing of Lubricants

Cleveland Section Paper

By E. Wooler[1]

INABILITY of the roller-bearing company with which the author of this paper is connected to obtain from oil manufacturers or others the information it desired regarding the properties of lubricants for transmissions and rear axles caused the company to undertake to secure the information at first hand itself. It began testing lubricants for their abrasive qualities and their load-carrying capacities.

The investigators soon realized that the usual physical tests do not prove the effects of lubricants on gears. Therefore two machines were built, one to give the scuffing properties and the other to give the abrasive properties, the latter being the more important as regards antifriction bearings. Lubricants of mineral origin that were free from fillers and metallic substances were satisfactory in this respect, but many gears require a lubricant that will withstand gear-tooth loads as high as 1800 lb. per in. of tooth length, which is higher than the straight mineral oils can carry without scuffing.

The test machines built and their operation are described. Results obtained with various oils and compounds are shown in photographs of test blocks and in autographic records made with apparatus designed at the University of Michigan for checking the roughness of plane or curved surfaces. Charts are also given of coefficients of friction, oil temperatures, maximum load carried at different rubbing speeds before scuffing begins, and abrasion of bearings during test runs that were continued for 200 hr.

The lubricants tested included straight mineral oils and the same oils with the addition of varying percentages of free sulphur, combined sulphur, lead and copper oleates, lead oxide, aluminum stearate, inorganic fillers, cutting-oils and castor-oil.

The facts as determined up to the present with reference to lead-soap-base oils and sulphurized oils are enumerated and the desirable properties of a lubricant for heavily-loaded gears and hypoid gears are set forth.

In conclusion, the author states that the carrying capacities indicated are only comparative and that the results given are merely observations made in checking oils on the machines described. Since this investigation was initiated, several other gear, automobile and oil companies have done considerable work along the same line that is already beginning to be reflected in better oil products.

Written discussion on lead-soap-base lubricants and other types of lubricant for use in present-day transmissions and rear axles was contributed by five speakers, who present arguments for and against the use in them of lead soap, sulphur and other inorganic ingredients. A compromise between tooth scuffing and bearing wear seems to be necessary, according to one discusser, and the importance of designing gears with reference to the possible lubricating qualities of oils or greases is pointed out.

OUR LACK of knowledge about lubricants and our difficulty in obtaining the desired information from the oil industry, which did not seem to know or to be able to tell us what we wanted to know, led us to obtain the information for ourselves. The results of our findings, for which Mr. Boden, who has charge of the physical laboratory of the Timken Roller Bearing Co., with the cooperation of Mr. Maag, the company's oil chemist, are entirely responsible, are given in this paper. The paper does not actually condemn lead-soap oils as rear-axle lubricants. Apparently they are a necessary evil at present and undoubtedly were the salvation of hypoid-gear rear axles. They will withstand greater loads without breaking down than will straight mineral oils, but they are more abrasive. The facts, as we have found them in our tests, are given in the hope that they will promote a lively discussion.

Gear Lubrication a Major Problem

The lubricants discussed herein are those generally used in automobile transmissions and axles.

The increase in power and speed of automobiles in the last few years has made the problem of lubrication one of major importance in the engineering of all types of motor-vehicle. Lubrication of the engine has received considerable attention but that of the transmission and axle leaves much to be desired in many instances. The increased loads on gear teeth break down the oil film and score the gears when using straight mineral-oil lubricants, such as 600W. Therefore lubricants were compounded with a view to obtaining quieter gear action and increasing the load-carrying capacity of the gears.

Unfortunately, among the lubricants compounded were those having fillers and other ingredients that are abrasive agents, such as talc, mica, and asbestos and which not only lap the gears but also the bearings supporting them.

The introduction of hypoid gears brought the problem of lubrication to the forefront, as it was impossible to run these gears with straight mineral oil of suitable viscosity without trouble from scuffing.

For these reasons we began testing oils for their abrasive qualities and also for their carrying capacity, the two problems being inseparable, as will be shown.

The first attempt at determining the qualities of oil was to subject the oil to a four-square test, which is

[1] M.S A.E.—Chief engineer, Timken Roller Bearing Co., Canton, Ohio.

an apparatus described in the paper[2] I read before the Cleveland Section of the Society on Nov. 19, 1928. This test was a very good one but took a rather long time to run and necessitated four complete automobile rear axles for each test, so other means were looked for which would be quicker and cheaper and give results that were more comparable. We soon realized that the usual physical tests in use do not give the answer to the effect of lubricants on gears. The suitability of an oil was usually determined from its physical constants and the results obtained by service records and road tests.

Two machines were built, one to give the scuffing properties and the other to give the abrasive properties of oils. The abrasive testing is the more important as regards antifriction bearings, and, from this viewpoint, lubricants of mineral origin that were free from fillers and metallic substances were quite satisfactory, no trouble being experienced from abrasion. Many gears, however, demand a lubricant that will withstand much higher loads without scuffing.

E. Wooler

Increase of Gear-Tooth Loads

As is well known, high tooth-loads have become common in many axles in recent years, theoretical loads as high as 1800 lb. per in. of tooth length in high gear being not unusual. This has been caused by a desire to reduce the cost of the axle and transmission assembly, and, incidentally, to reduce the unsprung weight of the rear axle, resulting in the use of too small an axle under a car. Tooth pressures as used at present and some used by the same manufacturers five or six years ago are given in Table 1. The letters denote the makes of the car, and the tooth loads are those on the rear-axle gears of the same makes of car. Note that in Car D the tooth pressure in 1924 was only 925 lb., whereas now the tooth pressure in this same car is 1450 lb. Car G is now loaded 1570 lb. on the gear teeth, whereas in 1924 the tooth pressure was only 1170 lb. The gear in the car having an engine that gives 240-ft-lb. torque is loaded 1875 lb. per in. This is much too high a load for a straight mineral oil to carry.

The limit of load on the gear teeth has been figured in the past from strength of the material with little consideration for the limit of satisfactory lubrication. With excessive deflection in some carriers and in pinion and ring-gear assemblies, localized loads were so heavy that a definite breakdown of the oil film occurred, producing scored gears, and companies that were having trouble with scored gears demanded a lubricant which would prevent this scoring and save the gears from destruction. That lead-soap-base oils and those containing inorganic fillers would withstand heavier loads than a straight mineral oil has long been known. Therefore it was natural that the companies should go to these lead-soap-base oils to overcome this trouble from scored gears. They found, however, that when these oils were used considerable wear took place on both the antifriction bearings and the tooth profiles, eventually causing noisy gears. Consequently, we were anxious to know just what ingredients in these oils prevented scoring of the gears and those that caused lapping of both the gears and the bearings.

The test conducted on the four-square apparatus indicated conclusively that more lapping action occurred when using the lead-soap-base oils than when using straight mineral oils of the well-known 600W type. The increase in bearing wear amounted to between 25 and 100 per cent in 100 hr. of running.

Test Machine for Scoring and Scuffing

In an endeavor to ascertain the most suitable oils for hypoid gears and spiral-bevel gears in general, using antifriction bearings, a test machine was built as shown by Fig. 1. The construction and operation of this machine are as follows:

A mandrel is mounted on two bearings and has a tapered portion on its outer end on which a regular Timken bearing cup is held by means of a nut, as shown at the left in the cross-section drawing. Directly beneath the revolving cup, a test block ½ in. square by ¾ in. long is mounted on a lever, shown in the end drawing. This lever is supported on a knife-edge by a second lever, which is similarly mounted on a universal knife-edge on the base of the machine. This arrangement assures that the test block will at all times be parallel to the revolving cup so that the unit loading will be maintained constant over the length of the test piece.

The first lever is loaded by means of weights, thus producing a certain pressure per square inch of surface area in contact on the square test-block. The hardness of these two test pieces is the same both being hardened to Rockwell 60 on the C scale. The test-pieces are made of nickel-molybdenum steel, case-hardened and ground.

Four tests can be conducted on one test-block, but each new face tested requires a new cup on the mandrel. Two newly ground surfaces are then run together with the required load, assuring uniform test-

TABLE 1—INCREASE IN REAR-AXLE GEAR-TOOTH LOADS IN SIX YEARS

Make of Car	Engine Torque, Lb-Ft.		Axle Ratio		Tooth Load, Lb. per In.	
	1924	1930	1924	1930	1924	1930
A	78	107	..	..	875	885
	...	114	..	4.7	....	1,400
B	95	115	4.7	4.7	1,185	1,430
C	110	122	4.7	..	1,540	1,500
D	126	130	3.7	4.7	925	1,450
	...	140	..	5.4	....	1,220
E	128	150	..	4.5	1,430	1,640
F	113	165	..	4.36	1,140	1,600
G	108	170	..	4.36	1,170	1,570
	...	178	..	4.4	....	1,700
	...	190	..	3.58	....	1,200
	...	225	..	4.9	....	1,440
	...	240	..	4.36	....	1,875
	...	250	..	4.23	....	1,350

Average increase in tooth load in Cars A, B, C, D, E, F and G from 1924 to 1930 equals 22 per cent.

[2] See S.A.E. JOURNAL, July, 1929, p. 68; also TRANSACTIONS, vol. 24, 1929, p. 346.

results. The cup can be reground four or five times before being discarded, if desired, but we found it more economical to use a new cup for each test.

The second lever is a friction lever, and when this is balanced with weights the coefficient of friction of an oil can be determined.

A tank is mounted at the top of the machine and approximately 1 gal. of oil is placed in it. The oil is run by gravity over the test-block and is returned to the tank by means of a pump. The temperature of the oil in the tank was started at 100 deg. fahr. in the tests to be illustrated later, and the temperature of the test-block is also taken, giving an indication of the comparative temperatures. By this arrangement we approximate the condition in an axle in which the oil is splashed upon the pinion by the ring gear.

The tests have been run at a rubbing speed of 320 ft. per min., and the test is usually run for 30 min.

The question of a suitable rubbing speed at which to conduct these tests has not been thoroughly determined. As will be seen later, this is very important and greatly affects the load-carrying capacity of a lubricant. The rubbing speed along the profile of the teeth in some axles is in the neighborhood of 900 ft. per min. at approximately 1000 r.p.m., the rate varying for different types of gearing according to the combination of revolutions per minute, tooth form, pressure angle, and so forth. It may be desirable to make tests at two rubbing speeds, such as 200 and 300 ft. per min.

Loads at Which Scuffing Starts

Curve *E* in Fig. 2 is a friction curve for a straight mineral oil of 150-sec. viscosity at 210 deg. fahr., which shows rapid increase in friction at a load of 6000 lb. per sq. in. at a rubbing speed of 320 ft. per min. This is the point at which scuffing starts and is the maximum load this oil will carry at this particular rubbing speed. Curve *U*, for a straight mineral oil of 800-sec. viscosity at 210 deg. fahr., also shows a minimum friction and then a rise at 15,000 lb., which again checks the point of scoring. Four other friction curves are shown for 600W oil containing various fillers as specified in the caption under the engraving.

Fig. 3 is a photograph of four typical test-blocks after test. The block at the top was run with a straight mineral oil at 5000-lb. pressure, and the second with this same oil at 10,000 lb. The third block shows the effect of adding aluminum soap to the straight mineral oil, and the bottom block the effect of soda-soap addition. As can be seen, these additions do not greatly improve the carrying capacity of the oil. The curves to the right of the block show the roughness of the face as determined by apparatus designed for us by the University of Michigan, which can check the roughness of either plane surfaces or curved surfaces such as those of gear teeth. The magnification is approximately 500 times, so that ¼ in. in height of the actual size of the curve produced by the machine represents 0.0005 in.

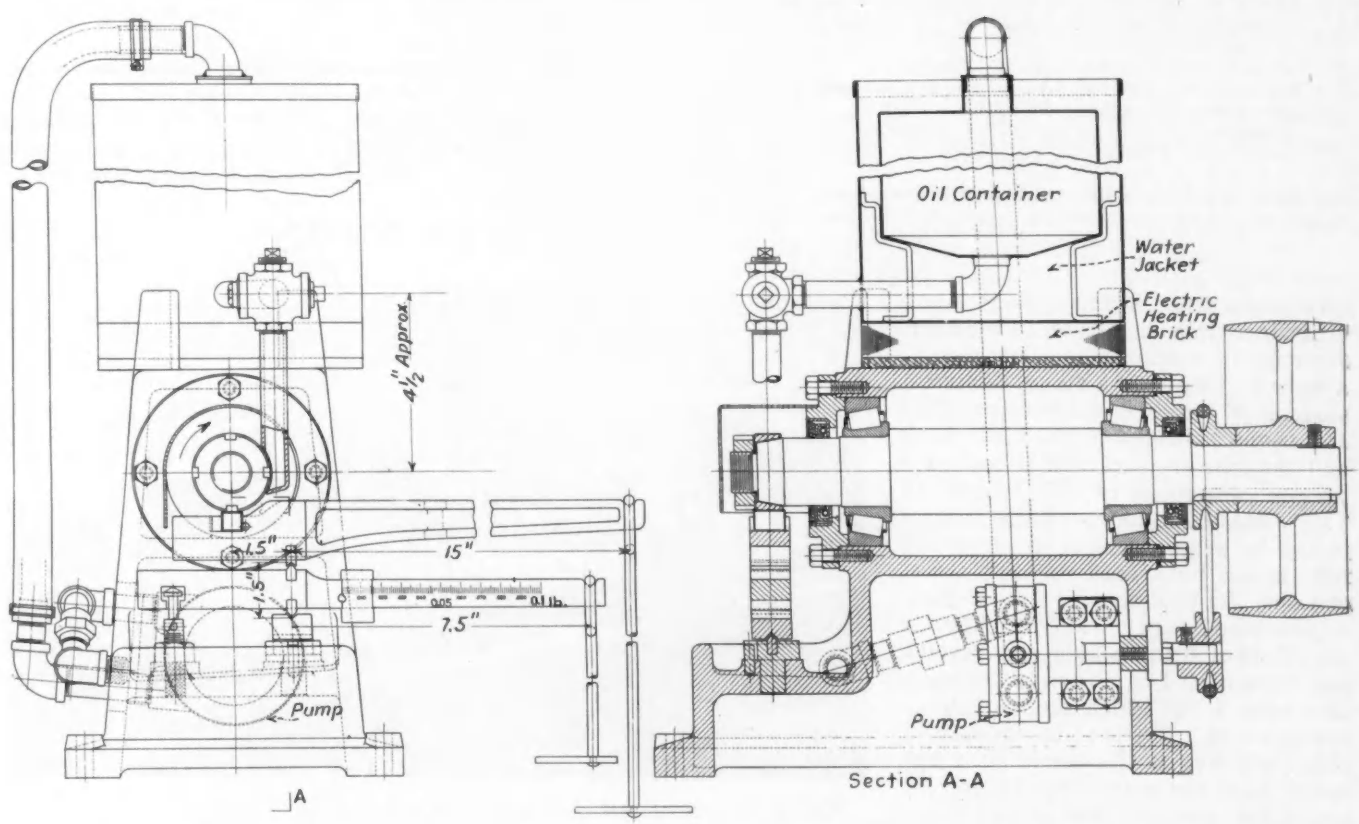


FIG. 1—TEST MACHINE TO DETERMINE LOAD-CARRYING CAPACITY OF LUBRICANTS FOR SPIRAL-BEVEL AND HYPOID GEARS

A Roller-Bearing Cup Is Mounted on the Left-Hand Beveled End of the Belt-Driven Mandrel and Held by Means of a Nut. Directly beneath the Cup a Square Test-Block Is Mounted on a Lever Supported on a Knife-Edge by a Second Lever, as Seen in the End View at the Left. The First Lever Is Loaded with Weights To Produce Any Desired Pressure per Square Inch on the Surface of the Test-Block in Contact with the Revolving Cup. The Second Lever, When Balanced with Weights, Gives the Coefficient of Friction of the Oil under Test. Approximately 1 Gal. of Oil Is Placed in the Tank at the Top of the Machine and Flows by Gravity over the Test-Block. Tests Usually Are Run at a Rubbing Speed of 320 Ft. per Min. and for a Period of 30 Min.

The width of the blocks is ½ in., so it will be seen that scuffing of the block is rather severe.

Machine for Recording Surface Roughness

Operation of the roughness-recording machine, which is shown in Fig. 4, is as follows:

Light from a source *A* is projected through a small hole in the stand *B* and through a lens *C* against a small mirror *D*, which is fastened to a razor blade attached to a lever *E*, hinged to a stand. A master surface, *F*, supports this lever so that any deviation between the test pieces and the master piece will be reflected by the movement of the mirror *D*. This reflected beam of light is projected to a second mirror, *G*, which reflects the light back through a second lens, *H*, (not shown) onto a piece of sensitized paper, *J*. This paper is placed on a drum which can revolve and is connected by a cord to the movable base, *K*, on which the test pieces are mounted. The base moves only in a straight line and is operated by the handle *L*, at the rear of the fixture. To test plane surfaces, the arbor is replaced by a suitable stand which also must carry a master test-piece.

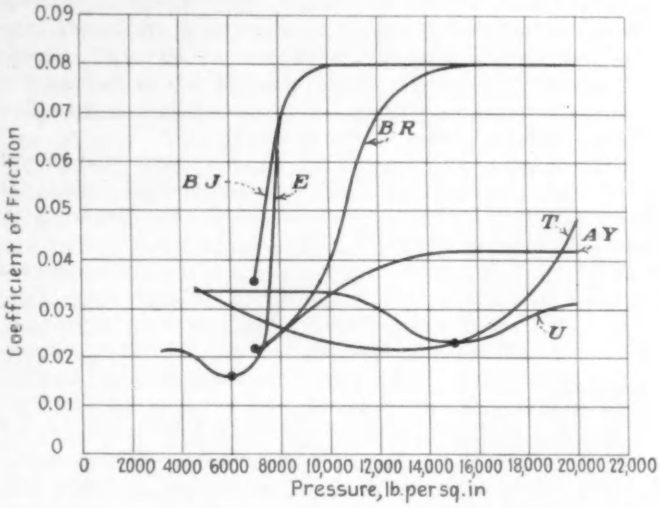


FIG. 2—FRICTION CURVES FOR TWO STRAIGHT MINERAL OILS AND FOUR COMPOUNDS

The Lubricants to Which the Letters on the Curves Refer Were
E—Straight Mineral Oil (600W) of 150-Saybolt-Sec. Viscosity at 210 Deg. Fahr.
BJ—600W Plus 2 Per Cent of Litharge
BR—600W Plus 5 Per Cent of Aluminum Stearate
AY—600W Plus 5 Per Cent of Lime Soap
T—600W Plus 2 Per Cent of Free Sulphur
U—Straight Mineral Oil of 800-Sec. Viscosity at 210 Deg. Fahr.
The Dots Indicate the Maximum Load before Scoring or Scuffing Starts, Which Is the Maximum Load the Oil Will Carry at the Rubbing Speed of 320 Ft. per Min.

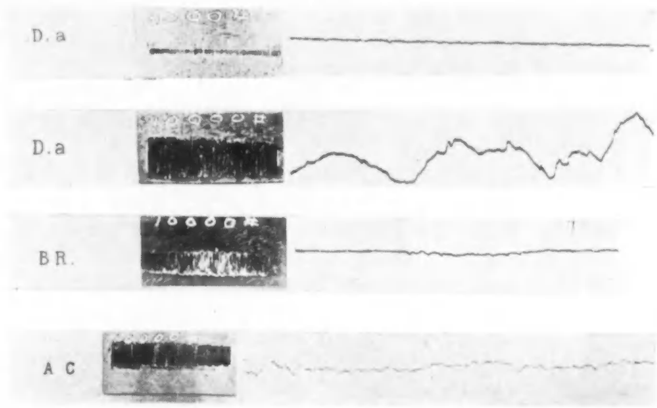


FIG. 3—TYPICAL RESULTS OBTAINED ON FOUR TEST BLOCKS, WITH GRAPHS SHOWING ROUGHNESS OF SURFACE AS RECORDED BY APPARATUS DESIGNED AT THE UNIVERSITY OF MICHIGAN

In Order from Top to Bottom the Results Were Produced at a Rubbing Speed of 320 Ft. per Min. with Oils and Pressures as Follows:
Da—Straight Mineral Oil at 5000 Lb. per Sq. In.
Da—Straight Mineral Oil at 10,000 Lb. per Sq. In.
BR—Same Oil with Aluminum-Soap Addition at 10,000 Lb.
AC—Same Oil with Soda-Soap Addition at 10,000 Lb.
Magnification of the Roughness Records, as Made by the Machine Is 500 Times and ¼ In. Height on the Records Represents Approximately 0.005 In. The Blocks Are ½ In. Wide. The Photograph Has Been Reduced in the Engraving to a Little Less than One-Half Size

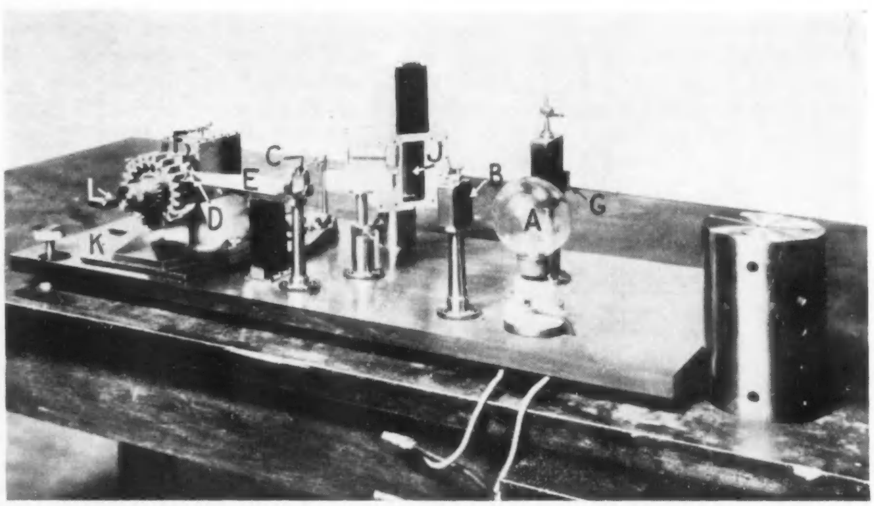


FIG. 4—MACHINE FOR AUTOMATICALLY RECORDING SURFACE ROUGHNESS

Light from Source *A* Is Projected through a Small Hole in Stand *B* and Lens *C* to a Small Mirror, *D*, Fastened to a Razor Blade Attached to Lever *E*. A Master Surface, *F*, Supports This Lever so that Any Deviation between the Surfaces of the Master Piece and Test Pieces Causes Movement of Mirror *D*, Which Reflects the Light Beam to Mirror *G*. This Reflects It Back through a Lens, (Not Shown,) to Sensitized Paper *J* on a Revolving Drum Connected by a Cord to the Base *K*, on Which the Test Pieces Are Mounted. Base *K* Is Movable by Handle *L* only in a Straight Line. To Test Plane Surfaces, the Arbor Is Replaced by a Suitable Stand That Must also Carry the Master Test-Pieces

Fig. 5 is a photograph of test-blocks after runs with five experimental oils made from Pennsylvania crude, which is extremely low in natural sulphur.

Oil AR was a straight mineral oil of 150-sec. viscosity at 210 deg. fahr. At a pressure of 10,000 lb. per sq. in. it produces a very bad score.

Oil AS was the same oil as AR but with the addition of 2 per cent of free sulphur. Fine scratches were produced in this test. The load was carried to 20,000 lb. per sq. in.

Oil AT had 2 per cent of lead oleate added to the

same oil as AR. No scratches are evident with this oil.

Oil AU had 10 per cent of lead oleate added to AR and the load was again carried to 20,000 lb. per sq. in. Again no scratches are observed.

Oil AV was made by adding together oils AS and AT, and therefore contained 1 per cent of lead oleate and 1 per cent of sulphur. Fine scratches are again noted, which shows that the sulphur was the cause of the scratches.

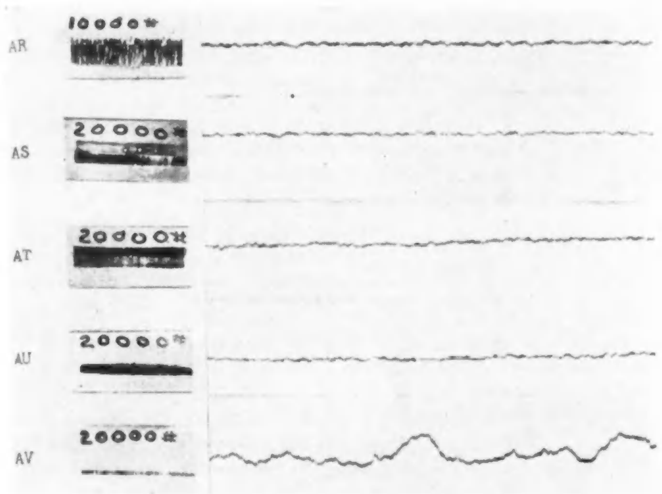


FIG. 5—TEST RESULTS FROM FIVE EXPERIMENTAL OILS MADE FROM PENNSYLVANIA CRUDE, WHICH IS VERY LOW IN NATURAL SULPHUR

The Pressures Were as Shown on the Blocks and the Oils Used Were as Follows:

AR—Straight Mineral Oil of 150-Saybolt-Sec. Viscosity at 210 Deg. Fahr. A Very Bad Score Was Produced

AS—Same as AR, with 2 Per Cent of Free Sulphur Added. Fine Scratches Were Produced

AT—Same as AR, with 2 Per Cent of Lead Oleate. No Scratches Are Evident

AU—Same as AR, with 10 Per Cent of Lead Oleate. No Scratches Are Evident

AV—Mixture of AS and AT, Giving 1 Per Cent Each of Sulphur and Lead Oleate. Fine Scratches Show that Sulphur Was the Cause

Curves of the coefficient of friction for these same oils, as given in Fig. 6, show that the friction increases with the increase of lead oleate.

Temperatures reached by these oils in the tank are plotted in Fig. 7. Here the sulphur oil shows the lowest temperature, as might be expected from the well-known cooling action when sulphur is added to hot journals. The highest temperature was reached with the high-lead-oleate oil. The friction curves in Fig. 6 follow the temperature curves in Fig. 7 in the same order.

Many oil compounds have been tested but the most promising as regards load-carrying ability are sulphur oils and lead-soap-base oils.

Results with Lead-Soap and Sulphur Oils

Test results obtained with lead-soap oils are shown in Fig. 8.

Oil AX is a well-known brand of lead-soap oil containing sulphur.

Oil AJ is a similar lead-soap oil.

Oil BF is another, containing approximately 7 per cent of lead soap and no sulphur.

Note that with no sulphur and a low lead-soap content the load-carrying capacity is very low. The tests indicate that, with various percentages of lead soap, the sulphur content should be varied to obtain constant results. Relatively high loads can be carried with a high lead-soap content and little or no sulphur, but to hold high percentages of lead soap in permanent suspension is very difficult if not impossible.

Test results obtained with sulphur oils are shown in Fig. 9.

Oil BT had 20 per cent of added sulphur.

Oil BU had 10 per cent of added sulphur. In this case the sulphur supposedly was added onto the hydrogen atom.

Oil BV contained 10 per cent of combined sulphur, the sulphur atom replacing a hydrogen atom and therefore being in chemical combination.

The results of this test are interesting as showing the abrasive qualities as well as the carrying capacity of an oil that is high in free sulphur (BT). This is

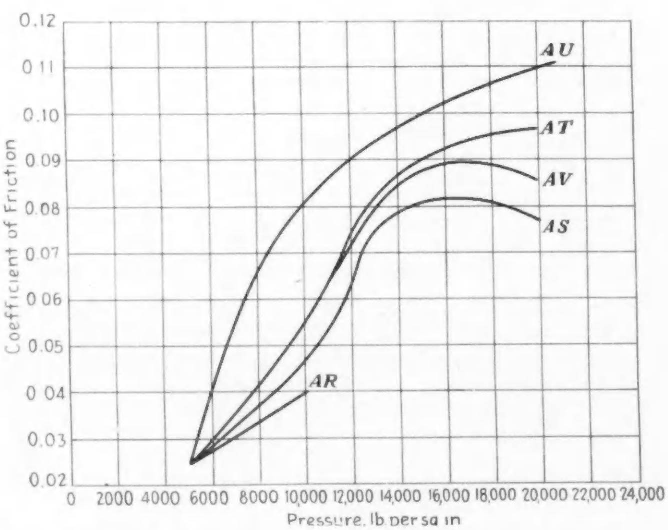


FIG. 6—CURVES OF COEFFICIENT OF FRICTION OF OILS THAT PRODUCED THE RESULTS SHOWN IN FIG. 5

The Rubbing Speed Was 320 Ft. per Min. Note That the Friction Increases with Increase of the Percentage of Lead Oleate in the Oil

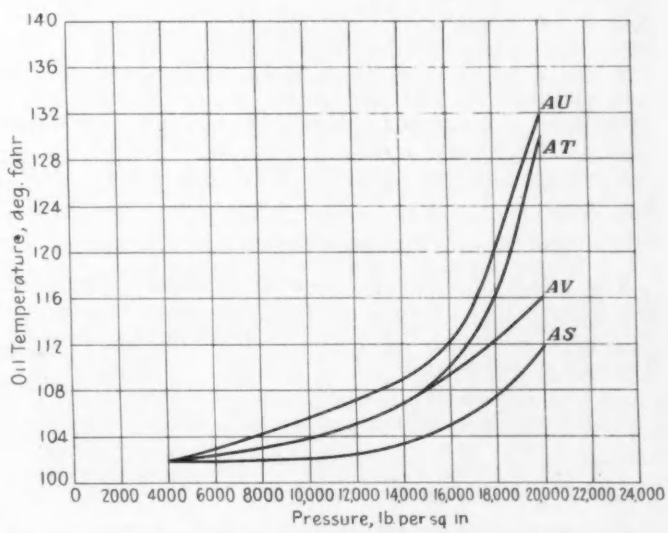


FIG. 7—CURVES OF TEMPERATURE REACHED BY OIL IN THE TANK DURING TESTS RECORDED IN FIG. 5

These Follow the Friction Curves in the Same Order of the Oils. The Sulphur Oil Shows the Lowest Temperature, as Might Be Expected, and the Lead-Oleate Oil the Highest Temperature

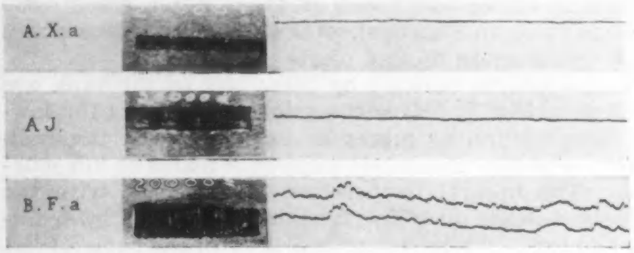


FIG. 8—TEST RESULTS WITH LEAD-SOAP OILS

Oils AXa and AJ Are Brands Containing Sulphur; Oil BFa Contains Approximately 7 Per Cent of Lead Soap and No Sulphur. Relatively High Loads Can Be Carried with a High Percentage of Lead-Soap Content, but To Hold a High Percentage in Suspension Is Very Difficult

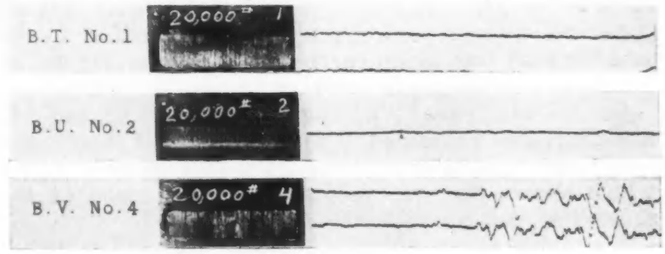


FIG. 9—TEST RESULTS WITH SULPHUR OIL

Oil BT Had 20 Per Cent of Sulphur Added, and Oil BU Had 10 Per Cent, Supposedly Added onto the Hydrogen Atoms. Oil BV Contained 10 Per Cent of Combined Sulphur Replacing Hydrogen Atoms. Free Sulphur Gives Good Carrying Capacity but Has Abrasive Qualities and Separates Badly from the Oil, Separation Did Not Occur with Chemically Combined Sulphur

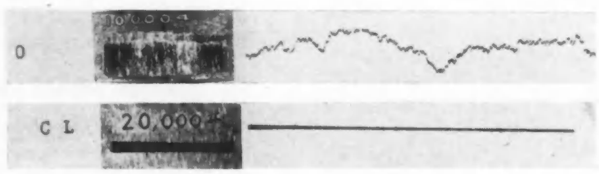


FIG. 10—TEST RESULTS WITH CASTOR-OIL AND WITH 600W PLUS 10 PER CENT OF CUTTING-OIL

Castor-Oil (O) Did Not Stand Any More Load than Did Straight Mineral Oil, although It Has a Low Coefficient of Friction and a Low Cold-Test Value. The Effect (CL) of Cutting-Oil Containing Sulphur Chloride in Chemically Combined Form Is Surprising, as the Sulphur Content Was not More than 0.5 Per Cent. The Rubbing Speed in All These Tests Was 320 Ft. per Min.

shown by the extreme width of the contact surface that has been very badly lapped. Most chemically combined forms of sulphur scored badly at 20,000 lb. per sq. in. and would carry loads of only 10,000 and 15,000 lb.

Sulphur oils that are high in free sulphur separate badly in test and, to some extent, when standing for relatively short periods. Of the three oils represented in Fig. 9, oil BT separated badly in test and oil BU separated slightly after standing approximately one month. No separation occurred in the oil BV, which was chemically combined.

The effect of castor-oil at a load of 10,000 lb. per sq. in. is shown in Fig. 10. We were surprised to find that this oil did not stand any more load than straight mineral oil, commonly known as 600W. The advantage of this oil is its low coefficient of friction and low cold-test value. The result obtained with an addition of 10 per cent of a cutting-oil to a straight mineral oil of 150-sec. viscosity at 210 deg. fahr. is also shown. This cutting-oil is a sulphur chloride of chemically combined form. The results obtained were very surprising, as the sulphur content of the mixture did not exceed 0.5 per cent.

Relation of Rubbing Speed to Pressure

The effect of rubbing speed in relation to pressure per square inch, before scuffing, has been determined for three different types of oil, as shown in Fig. 11. The oils tested were:

(*A*) Lead-soap oil
(*B*) Straight mineral oil of 150-sec. viscosity at 210 deg. fahr.
(*C*) Oil B with 3 per cent of flowers of sulphur cooked into it.

The curves are extremely interesting as showing the importance of rubbing speed in relation to pressure. This brings up the question of whether a standard means of testing the load-carrying capacity of an oil is desirable. My opinion is that it is more essential to analyze an oil for its load-carrying capacity than to apply the physical tests made on lubricants in the past. Rubbing speeds of standard values should be adopted. As previously mentioned, the finding of a value at low speed and high load, and a value at high speed and low load may be necessary to determine the merit of an oil for the service intended.

Most of the lead-soap-base oils on the market contain sulphur varying in percentage up to 3¼ per cent

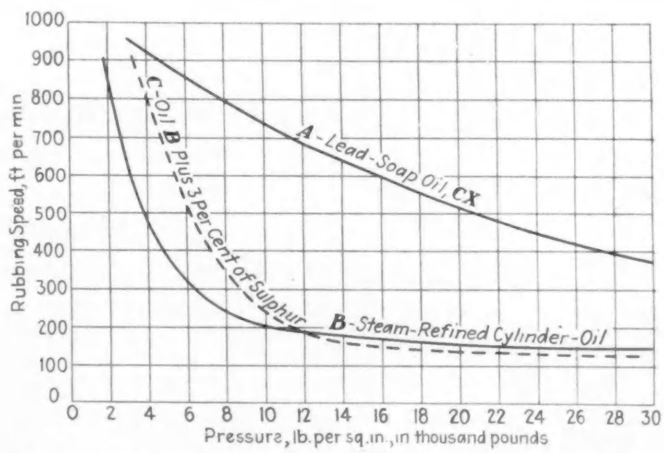


FIG. 11—RELATION OF RUBBING SPEED TO PRESSURE BEFORE SCUFFING STARTS OR EXCESSIVE ABRASION OCCURS

Solid Lines Show Loads before Scuffing; the Broken Line, before Excessive Abrasion. A Low-Speed and High-Load Value and a High-Speed and Low-Load Value May Be Necessary To Indicate the Merit of an Oil for the Service Intended

and in various forms, from free to chemically combined form. The sulphur content undoubtedly accounts for these oils withstanding heavy loads, as it is found that when a lead-soap-base oil does not contain any appreciable quantity of sulphur it must contain at least 10 per cent of lead oleate. Much of the trouble in the past evidently has been experienced in trying to hold in solution a high percentage of lead soap. Upon sepa-

ration, the lubricant from the bottom of the container will be high in soap content and inorganic matter. This will produce excessive wear. On the other hand, lubricant from the top of the container will not have sufficient carrying capacity to withstand heavy loads.

Tests Made with Different Metals

The effects of adding 0.5 per cent of water to three oils are shown in Fig. 12. The oils used were

(1) Straight mineral oil, 600W
(2) Smackover crude, which is a natural sulphur-oil
(3) Straight mineral oil (600W) with 2 per cent of free sulphur added.

Our experience is that when sulphur is in a free state considerable discoloration is produced, which is obviously undesirable in antifriction bearings. The effect of discoloration on natural sulphur-oils is much less marked and perhaps no trouble would be experienced with this oil.

Tests have been made on different alloys of steel using steam-refined cylinder-oil in all cases. The difference obtained in the load-carrying capacity was very slight, not exceeding 1000 lb. per sq. in. at a rubbing speed of 320 ft. per min. The indications were that the high-nickel steels gave about the best results, but the increase was so small that it can be neglected.

A friction curve for phosphor-bronze when run against a hardened-steel cup is presented in Fig. 13. The phosphor bronze was composed of 80 per cent copper, 10 per cent tin and 10 per cent lead, and straight mineral oil was used in this test. The maximum load before marked scratchings occurred was 4000 lb. per sq. in. Definite scratching occurred at a higher load, and at 6000 lb. per sq. in. rapid wear set in. This load figure is the same as that at which steel starts to scuff when the same lubricant is used at the same rubbing speed. Wear is accelerated beyond this figure, and, as seen at 20,000 lb. per sq. in., considerable wear has occurred, although the surface is relatively smooth.

Machine for Testing Abrasive Properties

A machine built to make comparative tests of the abrasive properties of lubricants is shown in Fig. 14. It embodies four pinions, each mounted on two bearings and driven by a single ring-gear. This machine is mounted in a vertical position and driven by a vertical electric motor through a belt drive. The pinions are run at 2000 r.p.m., and the lubricant is supplied to the gearbox and circulated through pipes to the four pinion-housings. On the end of each pinion-shaft is mounted a fan having four blades 5 in. wide by 6 in. long. The outside diameter of the fans is $16\frac{1}{2}$ in. This arrangement gives a load of approximately 8 hp. and is also the means of cooling the oil to a constant temperature of about 150 deg. fahr.

The bearings on the pinion-shaft are measured for over-all height before and after the test, which is run for a period of 200 hr. The difference in height is the drop of the bearing, and the average drop of the bearings on the pinion-shaft is taken as the measure of the abrasive property of the lubricant. Under these conditions, a straight mineral oil will give a total wear of approximately 0.0015 in. on the two pinion-shaft bearings in 200 hr. It is important, when testing bearings for wear, that the load be applied on the bearings in the same way that it will be applied in service. In the case of the pinion bearings, the load from the pinion teeth is applied outside of the bearing axis and, when considering the thrust load in particular, produces more bearing wear than when the load is applied through its axis. This is the reason for building this machine, and the results obtained have justified its development.

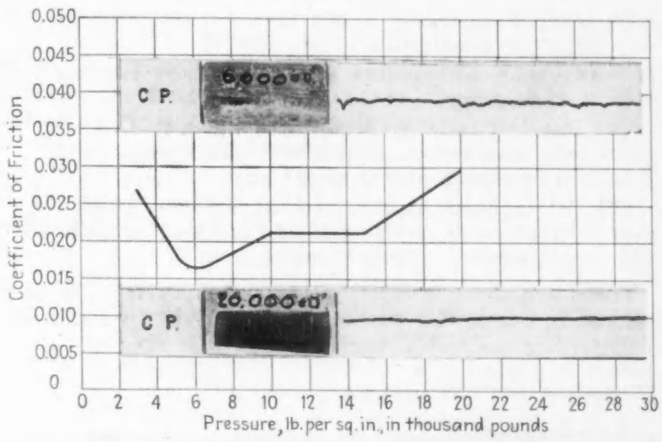


FIG. 13—FRICTION CURVE OF PHOSPHOR-BRONZE RUN AGAINST A HARDENED-STEEL CUP, USING STRAIGHT MINERAL OIL

The Bronze Contained 80 Per Cent Copper, 10 Per Cent Tin and 10 Per Cent Lead. The Oil Was Steam-Refined Cylinder-Oil, and the Rubbing Speed Was 320 Ft. per Min. Rapid Wear Started at a Load of 6000 Lb. per Sq. In., Which Is the Same Load at Which Steel Starts To Scuff. At 20,000 Lb. Considerable Wear Has Occurred, although the Surface Is Relatively Smooth

Results obtained with some of the oils tested are represented by the curves in Fig. 15, which show comparative amounts of wear up to 200-hr. duration. These reveal that straight mineral oils of 150-sec. viscosity, which was the lowest viscosity of the oils tested, gives the minimum amount of wear. Abrasion is increased when ingredients are added to the oil, the amount of abrasion depending on the type and quantity of the substances present. Note that the chemically combined sulphur-oil of 3 per cent sulphur, which was a Smackover oil, showed very little increase in abrasion over straight mineral oil, and that wear occurred with lead-soap and copper-oleate oils, that separate badly.

Conclusions Based on Tests Made

The facts as seen at present may be stated briefly as follows:

(1) Lead-soap-base oils have not been compounded so as to produce dependable products

FIG. 12—EFFECTS OF ADDITION OF WATER TO OILS

Discoloration of Bearing Cups Caused During 50-Hr. Immersion by Adding 0.5 Per Cent of Water to (Left) Straight Mineral Oil, 600W, (Center) Smackover Crude, Which Contains 3 Per Cent of Natural Sulphur, and (Right) Oil 600W Plus 2 Per Cent of Free Sulphur

(2) Inorganic fillers that are lapping agents, such as talc, mica, graphite and asbestos, should not be used.

(3) An oil that is desirable for heavily loaded gears and hypoid gears should have the following characteristics:

(a) Freedom from separation on standing and in service

(b) The minimum abrasive property

(c) Ability to carry a certain load on a suitable test-machine at specified rubbing speeds without scuffing

(d) Freedom from channeling at low temperatures

(e) Be reasonably cheap and obtainable at any service station

(f) Shall not produce etching or discoloration of bearings, and the like

(4) Physical tests, such as those illustrated, should be used in conjunction with the regular physical constants used in the past

(5) A standard physical-test apparatus should be used to determine the load-carrying capacities and freedom from abrasion

These are items which the Lubricant Division of the Standards Committee of the Society might consider investigating.

[3] Standard Oil Co. of Ohio, Cleveland.

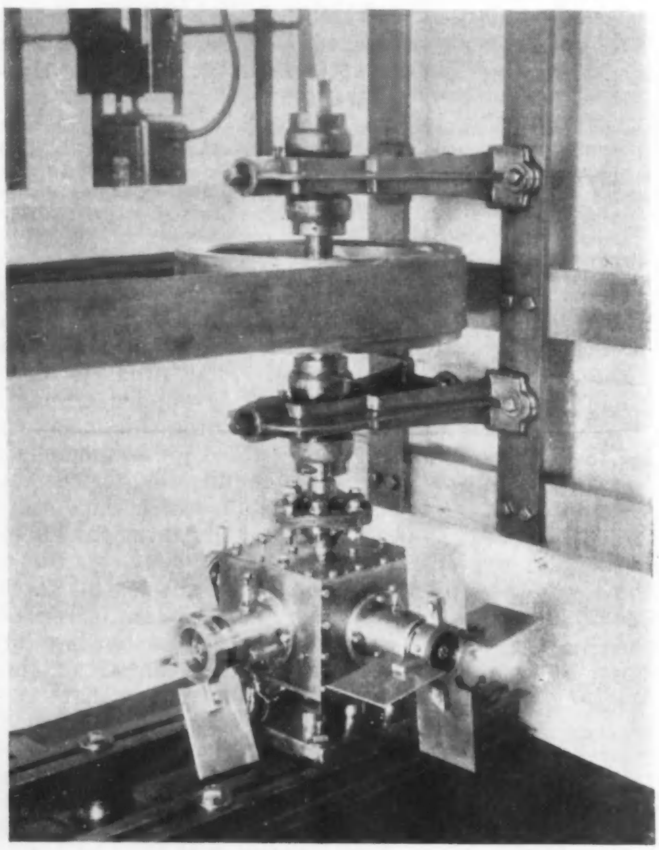


FIG. 14—MACHINE FOR TESTING ABRASIVE PROPERTIES OF LUBRICANTS

Four Pinions, Each Mounted on Two Bearings, Are Driven by a Single Ring-gear. Lubricant Is Supplied to the Gearbox. Each Pinion-Shaft Carries a Four-Bladed Fan. The Fans Impose a Load of Approximately 8 Hp. and Cool the Oil to about 150 Deg. Fahr. The Amount of Abrasion of the Bearings Is Determined by Measuring Their Over-All Height before and after Test

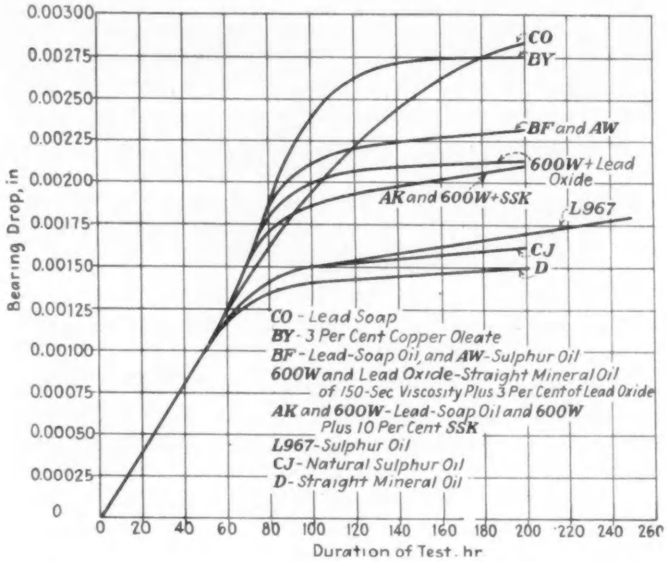


FIG. 15—COMPARATIVE AMOUNTS OF BEARING WEAR WITH VARIOUS LUBRICANTS

The Curves Are for Average Drop in Over-All Height of Two Pinion Bearings during a 200-Hr. Test with a Pinion Speed of 2000 R.P.M. The Curves for BF and AW Coincide. The AK and 600W Compound Contained 10 Per Cent of Cutting Oil

In conclusion, I desire to state that the load-carrying capacities indicated herein are only comparative in their nature; they should not be construed as being absolute values. I have not attempted to show that any particular oil is best suited for use in axles and transmissions. The results outlined are merely observations made in checking oils submitted by different manufacturers on the machines illustrated.

Since the initiation of this work by ourselves and several other interested companies, including the General Motors Corp. and the Gleason Works, oil companies in general have done considerable work that is already beginning to be reflected in better oil products.

THE DISCUSSION ON LEAD-BASE LUBRICANTS

L. B. HELM[3]:—In discussing lead-base lubricants, it seems that three objects must be taken into consideration:

(1) Protection of the gears

(2) Protection of the roller-bearings

(3) Construction of the gears in such a way that it will be practicable for the oil manufacturer to produce a product that will lubricate them safely.

First, it would seem that the manufacturer of the gears should hesitate to go into the manufacture of as intricate a gear as the hypoid until he has consulted with the lubricant manufacturer to see if it will be possible to produce a satisfactory lubricant for this type of gear.

Second, the gear manufacturer must take into consideration the fact that the lubricant must contain nothing that will be injurious to the roller-bearing. Serious consideration must be given to the use of com-

bined sulphur in the lubricant, because of its potential corrosive effect and also its abrasive action. Many persons contend that the combined sulphur in the petroleum does not create these hazards; therefore it seems safe to recommend as a base for the lead lubricant the use of petroleum that is reasonably high in combined sulphur.

Third, the oil manufacturer cannot instantly produce a satisfactory oil that can be put into the gearcase and become an immediate success as a lubricant for a high-speed high-pressure gear. On the contrary, he must put on an intensive campaign of research and experimenting to develop a worthy product before he offers it to the public.

The high speed, high pressures on the gears and the resulting high temperatures make the use of a straight petroleum oil seem impracticable because of the tendency of the oil film to break down and cause scoring of the gears. There are, however, a few exceptions to this statement. It would seem to be more feasible to begin with a light oil and build up the film structure by the addition of lead in chemical combination.

Oiliness an Important Factor

With pressures exceeding 7000 lb., the property of oiliness becomes an important factor. This may be defined as the property of an oil to enter into molecular arrangement with the metal. The oil is actually absorbed into the metal and the film is probably one molecule in thickness. Possibly the lead actually enters into this union. In such a case the lead would serve only to increase the oiliness. From this, apparently all that is necessary is to build up the oil film directly in proportion to the maximum temperature that will be attained.

In the manufacture of lead soap, the compounds are formed by the reaction of lead oxide upon some fatty oil, preferably one high in olein, the ease with which the reaction takes place being dependent to a great extent upon the degree of unsaturation of the fatty oil used, the highly unsaturated fatty oils being the best. Two distinct compounds can be formed; namely, basic soap and normal soap. The normal soap is quite soft and fairly soluble in mineral oil. This soap has a tendency to lower the viscosity of the basic oil, which would be highly desirable in a winter grade.

The basic soap differs from the normal soap in that its lead content and its melting point are higher and its solubility in mineral oil is lower. It also has the property of increasing the viscosity of the basic oil to some extent. It has also been found in the use of basic soap that the viscosity of the finished product is more uniform than when the normal soap is used and that basic soap will stay in solution with the oil much better than the normal soap. Furthermore, it is questionable if a stratification of the products in the gear oil does not occur because of the difference in their molecular weights, although this has not been made apparent by research done on this subject.

Lead and Sulphur-Content Standard Needed

An endeavor to arrive at some basis of reasoning whereby a standard may be set up for hypoid or worm-gear lubricants would seem to be a practical undertaking. Some of the tests that we have made on various lead lubricants on the market seem to indicate that every man has a different idea as to what the lead and sulphur content should be. One company will produce a lubricant of 100 Saybolt seconds viscosity at 210 deg. fahr. having a lead content of 4 per cent found as PbO and very little sulphur, whereas another lubricant will be of 140-sec. viscosity at 210 deg. fahr. and contain very little lead and plenty of sulphur. Still another may be of 550-sec. viscosity at 210 deg. fahr. and be a straight mineral oil.

By standardization of this product I do not mean that we should specify certain conditions which would work hardships upon anyone, but that some understanding should be had as to what is regarded as a limit in the addition of sulphur, for surely there is a point at which the sulphur content becomes a hazard. A maximum lead-content should also be specified because there can be too much lead. Certainly the higher we go in lead content, the more chance there is of having an injurious amount of free lead in the product.

I contend that some of the gear makers, in their tests of products for placing them on the approved lists, set their standard very high, thereby causing the lubricant manufacturers to go to extremes, so that the factor of safety in the product seems to be entirely out of proportion to the work the product is to do. Instead of this method, why not put the gear under actual running conditions and thereby prove or disprove the worth of the lubricant under the exact conditions under which it will be used? I hope that the stating of some of the problems involved and the expression of our views will bring out discussion that will clarify some of the difficulties involved in our efforts to manufacture a product that will lubricate safely and at the same time efficiently.

Raw Material Limits Lubricant Capacity

LOY BISSEL[4]:—As automotive equipment has been developed and requirements became more exacting, the oil industry has produced and marketed better lubricants to meet current conditions, so that gear lubricants which give satisfactory service with normal tooth pressures and rubbing speeds are now widely available.

Gear design and gear lubrication are mutually dependent. They must move forward together, as improved gear design is useless without satisfactory lubrication.

Mr. Wooler's statement that "The chief concern of companies who found they were having trouble with scored gears was to find a lubricant which would prevent this scoring and save the gears from destruction," seems to indicate the advisability of closer cooperation between the automotive industry and the manufacturers of gear lubricants before the production of gears is started. Gear design has, in some cases, moved forward in the matter of tooth pressures and rubbing speeds to a limit which the best straight products of petroleum cannot reach with the necessary margin of lubrication safety.

To design and build a successful gear and make possible the operation of that gear by satisfactory lubrication are matters of experience, common sense and right materials. Contrast the materials available to the gear designer and to the oil refiner. Modern alloy steel and heat-treatment have given the gear designer materials of such high quality as to permit refinement of design, reduction of weight, and ability to withstand higher tooth pressures and rubbing speeds if properly lubricated. The limits of oil are narrower and more rigid than are those of steel. The film strength, the resistance

[4] Engineer, Standard Oil Co. of Ohio, Cleveland.

to heat and the stability of petroleum lubricants are limited by the raw material.

Most of the industrial machinery of the world, with its difficult and endless problems, is being successfully lubricated with products of petroleum unfortified and uncontaminated by solid material. The addition of sulphur or metallic soaps to lubricating oils may be necessary to meet abnormal conditions of gear design, but such compounded products bring with them the problem of keeping the added material in suspension and the possibility of abrasion and corrosion. Lubricants of this type, although satisfactory when first made, may, during necessary periods of storage, become unsuitable for severe conditions. The use of the same oil for gears and the roller-bearings in their assembly makes the factors of abrasion and corrosion more serious. For these reasons experienced manufacturers of lubricants hesitate to market compounded oils of this type, preferring to meet their problems with products that are free from the possibility of abrasion, corrosion and separation.

The Two Courses That Are Open

If, as the experience of the automotive industry seems to indicate, gear-tooth pressures and rubbing speeds are increasing beyond the safe lubricating capacity of straight petroleum products now commercially available, two courses are possible: (*a*) to develop and market lead-soap-base or other compounded oils that will meet abnormal conditions, with the disadvantages that go with them; or (*b*) to limit gear design to pressures and speeds that will make possible safe lubrication by commercially available lubricants which are free from the bad qualities mentioned.

If the automotive industry requires compounded lubricants such as lead-base compounds, they will be produced and marketed. They may or may not solve the problem satisfactorily. A common-sense compromise between gear design and the limitations of oils that are free from the dangers of abrasion, corrosion and separation may be advisable.

Careful consideration by all is deserved by Mr. Wooler's statements that "speeds and the loading of gears have increased to such an extent that high tooth-loads are quite common in many axles," and that "with excessive deflection in some carriers and pinion and ring-gear assemblies, localized loads were so heavy that a definite breakdown of the oil film produced scoring on the gear teeth."

Extreme qualities in one direction are sometimes obtained by the sacrifice of other qualities equally important.

The designer of a notably successful continuous mill made the following statement; "The success of this mill depends on lubrication. I designed the lubrication system first and built the mill around it." The results proved his wisdom. He, too, made use of high tooth-pressures and rubbing speeds, but he kept within the margin of safety of oils proved by time and experience. The lubrication of his gears and pinions is in the hands of experienced engineers.

Much automotive equipment is in unskilled hands, subject to abuse, neglect of lubrication and mechanical adjustment, and to extreme temperature changes. Gear assemblies that show good results in the laboratory or under the supervision of skilled mechanics may and do fail under the rough-and-tumble conditions to which much automotive equipment is exposed. In some cases the margin of gear-lubrication safety is too small.

Granted that compounded oils may be developed to meet the extreme conditions under discussion, the operators of automotive equipment will continue in many cases to drive into cross-roads service stations that have neither the lubricants nor the trained operators to meet difficult gear requirements. Is it not wiser, therefore, to market gear assemblies that will operate successfully with oils of average good quality, obtainable commercially wherever automotive equipment is serviced, rather than to produce gears which may fail unless protected by a limited number of special lubricants not obtainable at many service stations?

A Problem of Boundary Lubrication

A. E. BECKER[5]:—The papers presented are further evidence that the industry is alive to the fact that the whole question of transmission of power from the engine to the rear wheels needs more intensive study than it has been given. In discussing them, we are primarily concerned with the lubrication of transmission and differential units as they exist today and whether these designs are based on sound fundamental principles.

With regard to transmissions, we are concerned entirely with rolling friction, which is easily lubricated with a straight mineral oil. As Mr. Wooler states, however, the attempt has been made to subdue gear noises by resorting to higher viscosity and compounded lubricants. This has resulted in difficult gearshifting in cold weather, on the one hand, and, on the other, in separation of the lubricant ingredients and channeling troubles in service. By designing these units so that a high-viscosity lubricant is not required to quiet the gears or permit noiseless gearshifting, these problems disappear. Moreover, the same lubricant could then be used both summer and winter, which would be a decided advantage to all concerned. Solution of the present transmission problem is design, not compounded lubricants, since the latter have no legitimate place where pure rolling friction is involved.

What has just been said about transmissions applies equally well to those differentials in which straight rolling friction is involved and in which it is not necessary to prevent leakage and noise by resorting to high-viscosity oils and greases. Our tests indicate that the very use of the latter in new cars aggravates the leakage problem by filling the pores of the felt washers to such an extent that they no longer function as intended. A relatively low-viscosity oil is again correct for a properly designed unit of this type.

Worm and hypoid-gear drives have mechanical and gear-reduction advantages that are not possessed by bevel-gear drives, which makes imperative the solution of the lubrication problem involved. In a worm drive there is straight sliding friction, while in a hypoid gear we are concerned with both rolling and sliding friction, and, as pointed out in the papers, the loads involved are so great that it is impossible to obtain fluid-film lubrication. The problem is one of boundary lubrication.

Compounded Oils Act as Abrasives

Mr. Wooler states that the two problems of abrasive qualities and carrying capacity of lubricants are inseparable. From our present knowledge of boundary

[5] M.S.A.E.—In charge of fuel and lubrication section, Standard Oil Development Co., Elizabeth, N. J.

lubrication, we may go further and state that it is impossible to increase the carrying capacity of an oil without at the same time also increasing its abrasive qualities. It has long been known that small percentages of sulphur in an oil, either free or in chemical combination, permit increased loads to be carried in the field of partial lubrication, but always at the expense of wear. Some years ago we conducted experiments in which loads of several thousand pounds per square inch were carried satisfactorily with oil-bath temperatures of 500 deg. fahr. when using such lubricants. The bearing surfaces were always found to be in first-class condition after such experiments, but the amount of abrasive wear was so large as to preclude their use except as emergency lubricants, either to permit limited additional operation of the equipment or to recondition the bearing surfaces. This is also the function of graphite, mica, rouge, and like materials.

With straight mineral oils, fluid-film lubrication persists up to loads of a few hundred pounds per square inch. The amount of wear produced is negligible, as there is no metal-to-metal contact. When film rupture occurs, however, there is little reserve carrying capacity. Apparently, the adhesion between such an oil and metal is largely, if not entirely, physical in character. Consequently the surface film fails soon after fluid-film rupture occurs, with consequent scoring caused by actual metal-to-metal contact.

In the case of compounded oils, the action may be visualized somewhat differently. An oil containing sulphur functions much as a straight mineral oil in the fluid-film region. When this film is ruptured, the sulphur forms sulphides on the exposed portions of the bearing surfaces. These sulphides are then worn away by the rubbing action. The new surfaces so formed are again coated with sulphides and the action is repeated. The sulphides removed become very mild lapping agents, acting much as would graphite, mica or rouge under the circumstances. The combination of chemical action and abrasion finally results in 100-per cent bearing area, with consequent decrease in localized loading. On this basis, we have shown that a straight mineral oil of only 100 sec. Saybolt at 100 deg. fahr. can be made to carry 10,000 lb. per sq. in. after the surfaces are thus prepared with sulphur, graphite or some other known boundary lubricant. The primary function of compounding and filling agents appears, therefore, to be largely to keep the bearing surfaces in first-class condition, the oil doing the rest. The success of hypoid gears, therefore, seems to hinge upon whether a satisfactory compromise between carrying capacity and wear increase can be effected.

Research Promises an Improved Product

C. R. NOLL[6]:—The development of an entirely satisfactory lubricant for transmissions and differentials is an outstanding lubrication problem today. Lead-soap-base greases and their manufacture are not new to the grease maker and oil refiner. If there is a decided superiority in such products, when considered from all angles, this superiority should have led to more general use of such lubricants. There seems to be fairly general agreement that, if properly manufactured, such greases have the capacity to carry somewhat greater loads than a straight mineral oil of the usual transmission-oil specifications. This ability may be due to the property of lead-soap lubricants to be adsorbed and to spread better than straight mineral oils on metallic surfaces, tending to maintain a more continuous lubricating film on the gear teeth, and to the characteristic of the lead soap to decrease the interfacial tension between the metal and the lubricant. However, the undesirable abrasive characteristic of lead-soap-base greases as at present manufactured, which causes greater wear of bearings and the profile of gear teeth, seems to more than offset their advantages.

The large amount of research work that is now being done on this subject by both gear manufacturers and oil refiners seems to make reasonable a belief that more satisfactory products will be produced in the near future. These products may take the form of improved lead-soap-base greases or greases made from other metallic soaps. Probably a more desirable product may result if a straight mineral oil of suitable characteristics is developed, so processed or compounded as to provide ample protection against scuffing of gears at the highest rubbing-speeds and pressures encountered in operation. If such oils are developed, they should be superior to soap-thickened lubricants because of the undesirable characteristic of soap to separate from soap-thickened lubricants under high operating-temperatures and pressures, as well as the undesirable lapping action of some soaps.

Reduction of Consistency Objectionable

The use of lead soaps in transmission and differential lubricants seems to produce greases more of the nature of semifluid oils as compared with the more gel-like consistency of greases obtained through using the same quantities of other soaps usually used for such work. Therefore, to make a heavy lead-soap-base grease that is suitable for summer operation of certain equipment necessitates the use of an unusually large quantity of lead soap to secure the desired heavy consistency, with attendant greater possibility of soap separation. It has been found necessary to supply a heavier summer lubricant to many operators who do not keep in good condition such provisions as may be incorporated in the design for retaining the lubricant, with the result that lubricant works out of the housings and onto brake-bands and wheel spokes.

The type of oil used in the lubricant may have much to do with the expansion characteristic of the lubricant. Most commercial lead-soap-base rear-axle lubricants that we have examined contain from 5 to 15 per cent of lead soap and are thinner than the average summer lubricant made from other soaps usually used for this purpose. This point is mentioned as it is felt that an undesirably large percentage of lead soap may be found necessary in the finished lubricant to provide the relatively heavy lubricant demanded by certain operators for summer service.

Too Many Greases Specified for Servicing

One large manufacturer of worm-drive rear axles insists that only straight mineral oil or castor-oil be used in the worm gears manufactured by the company. We feel that, if a suitable heavy oil can be developed, this will greatly simplify the problem of supplying at service stations a satisfactory lubricant for rear axles of all designs, thus eliminating the necessity of having to stock several different lubricants at each service station to properly lubricate rear axles of different designs. This is emphasized clearly in Mr. Edwards' paper,

[6] M.S.A.E.—Automotive lubrication engineer, Gulf Refining Co., Pittsburgh.

which gives the specifications for rear-axle lubricant that are maintained by three different automotive and equipment manufacturers. To meet these specifications, the oil company must have two and possibly three lubricants available at each service station if the equipment driving up to that station is to be serviced with the lubricant recommended by the manufacturers of the vehicles. One can readily see how divergent specifications of this sort may spread and affect both the gear manufacturer and the refiner.

Greases Classified and Compared

VICTOR I. DOWNEY[7]:—For the last 10 years I have been in charge of a research laboratory specializing in the development and manufacture of lubricants. During that time we have analyzed hundreds of samples of greases and oils intended primarily for the lubrication of automotive rear-axle and transmission assemblies. We have also prepared experimentally and on a commercial scale hundreds of different products for this purpose.

Looking back over the various formulas and notes, we would probably group these products as follows:

(1) True greases containing calcium oleate or other calcium soaps as the solidifying or thickening agent

(2) True greases containing sodium oleate or other sodium soaps as the solidifying or thickening agent

(3) True greases containing aluminum oleate or stearate as the solidifying or thickening agent

(4) By-product greases which are primarily heavy, sticky residues from certain asphaltic crude oils or from cracking-still operation. A great many are made by oxidizing with air blown through the heated oil until the oil has thickened to the desired point

(5) Resin-oil mixtures. These are simple mixtures of hard resin and petroleum oil or, in some cases, mixtures of oil and a certain resinlike product from coking stills that is known to the refiner as "still wax"

No doubt all of these products have some merit now or have had some merit on motor-vehicle equipment as it was formerly manufactured.

Class 1 lubricants are subject to the following objections, which have already removed them from consideration as good lubricants for modern automotive transmissions: First (*a*) they require a definite percentage of moisture to assure stability; (*b*) to maintain this percentage exactly in present equipment is practically impossible; (*c*) this moisture is lost if the operating temperatures of transmissions rise to the boiling point; (*d*) the grease separates and its cushioning and lubricating power is gone; secondly, (*e*) the use of heavy oils is not easy, therefore the lubricating film is more easily ruptured and scuffing of the gears and later a noisy assembly result.

Class 2 greases have, up to the last year or so, provided the nearest approach to good practice that we have been able to find. We have been able to make semifluid products that afforded reasonably easy gearshift operation in cold weather. The tendency to foam has been very slight; consequently, loss and leakage have been low. Channeling also has been reasonably low. Grease of this type has had the great advantage that it clings to the meshing gears and works with the gears in a desirable way.

This grease has had the chief objection that it fails or goes to pieces when it comes in contact with moisture. This trouble was chiefly experienced when trucks were used in grading operations in which the wheels were often in mud and water until the axles dragged. Introduction of the steam-cleaning process for flushing out the old grease was a death blow to this grease, as it was practically impossible to remove all the moisture after cleaning the housing.

Class 3 greases have always been noted for their instability or tendency to separate.

Lubricants of Class 4 and 5 types will not permit easy shifting of gears in cold weather, and the loss of power in overcoming their cohesion is very high compared with that of the other groups.

Lead Soap Reduces Friction Coefficient

The recent introduction of new types of gear has caused a decided swing toward the use of a lead-soap grease or lubricant. This product was not included in the foregoing classes as it was decidedly in the minority until very recently.

Although this type of lubricant has long been known and used, and the number of patents issued for lubricants containing lead soaps runs into the hundreds, surprisingly little was actually known regarding the mechanism of the reaction between litharge and fish oil; in fact, the only definite authentic figures seem to be of very recent origin, namely, an article[8] by S. H. Diggs and F. S. Campbell, of the Standard Oil of Indiana. The new technique in lead-soap manufacture, namely pressure-kettle saponification, no doubt will overcome the difficulties that heretofore have existed in maintaining uniformity of the product.

Assuming that the formulas of Diggs and Campbell are correct and that a pressure kettle is used, with suitable pressure and temperature-recording devices, the laboratory control of raw materials should assure a more uniform product than has heretofore been possible in the manufacture of any type of grease.

A new instrument has lately been developed for determining the coefficient of friction of oils and greases. This is the Herschel oiliness tester developed by Dr. Winslow H. Herschel and Dr. H. C. Dickinson at the Bureau of Standards. On this machine all petroleum oils show the same coefficient of friction provided the viscosity is the same. The addition of fatty oils or fatty acids markedly reduces the coefficient, and introduction of lead soap reduces it very greatly; in fact, Dr. Herschel stated that a black, sticky grease containing 20 per cent of lead soap had the lowest coefficient of friction of anything he had tried.

We have found by experiment that gearshifting is easier, power losses are reduced, and channeling and foaming are virtually eliminated when suitable lead-soap fluid greases are used.

How Lead-Soap Greases Are Made

No doubt the question will be asked, Why, if this product is so good, was it not adopted earlier? For the answer, let us examine the early methods of manufacture and present-day transmission oils as used by the automobile manufacturers. According to Klemgard[9], a lead-soap grease can be made as follows:

[7] Director of research, National Refining Co., Findlay, Ohio.

[8] See *Industrial and Engineering Chemistry*, August, 1928, p. 828.

[9] See Lubricating Greases, by Edwin Neal Klemgard, 1927; Chemical Catalog Co., Inc., New York City.

Heat 550 lb. of whale oil to 475 to 525 deg. fahr. in a fire-heated grease kettle; add 209 lb. of litharge; agitate at above temperature for $1\frac{1}{2}$ to 2 hr.; add 4000 lb. of 60 at 210-viscosity black oil; cool to 150 deg. fahr. and draw into containers.

Checking these figures against those of Diggs and Campbell shows that a large quantity of unchanged fat would be present. In contrast, four lead greases from one company, when examined by us, showed an average of 35 per cent excess of lead over the theoretical quantity necessary for the fat.

At present 80 per cent of the transmission oils purchased by automobile manufacturers under S.A.E. Viscosity Nos. 90, 110 and 160 come from the Eldorado and Smackover districts in Arkansas. Fifty per cent of the crude oil from these fields goes direct to consumer from the wells as fuel oil at around 50 cents per barrel. The manufacturing process for these transmission oils consists of heating in a still to settle out the salt water and sand and drive off a very small percentage of light ends so as to give the desired flash-points and viscosity. The sulphur content rarely drops below 2 per cent. The carbon residue ranges from 4 to 8 per cent, and precipitation numbers vary according to purchasers' vigilance. The specifications of the General Motors Corp. call for not more than 0.03 per cent ash, a limitation that is intended to prevent excessive quantities of clay and sand.

Unsaturated Oils Liberate Free Carbon

Oils of this type were formerly, and are to a large extent today, used for lead-soap greases. Oil of another type that is used is heavy fuel-oil from cracking stills, which has a very high carbon-hydrogen ratio. This means unsaturation and ease of oxidation or decomposition.

We are of the opinion that several of the questions raised in Mr. Wooler's paper are directly traceable to the foregoing causes. Large excesses of lead oxide in lead greases have been common. Present equipment and practice make it possible to prevent its occurrence. High sulphur-content is inherent in the cheaper transmission oils, and this sulphur exists both as combined and elemental sulphur. One large automobile manufacturer requires $2\frac{1}{2}$ per cent of sulphur in his lead grease, as mentioned by Mr. Edwards. My thought has been that this specification was written from an analysis of a grease that was found to be satisfactory and in which the sulphur was present in the oil used and not added in the process of manufacture.

The use of highly unsaturated oils such as I have mentioned may be expected to liberate free carbon as fine particles of hard coke which tend to wear any bearing surface. We have found that these oils will coke in storage tanks when held under a temperature of 200 to 250 deg. fahr. for extended periods. Is it not reasonable to assume that oxidation and decomposition may occur in some of the high-speed transmissions in which the heat of the film must rise to these temperatures?

Part Played by Sulphur and Oxidation

Heretofore the lubricating engineer's idea has been that graphite, mica, arsenic, talc or sulphur, when added to bearings running warm, would cool these bearings by lapping them in or, on the other hand, by filling the rough places. I am not prepared to say to what extent this is true. The only one of these ingredients I have used outside of steel-mill work is flake graphite.

Mr. Wooler states that, unless sulphur is present, none of the lead-soap greases containing less than 10 per cent of lead oleate would carry the desired tooth load. This might be expected if the viscosity of the petroleum oil in the lubricant were too low. It would also account for trying to get a large quantity of lead soap to stay in the grease. For instance, suppose that we wanted to make a lead-soap grease having a finished viscosity of 120 at 210 U. S. We might put 5 per cent of the lead soap in an S.A.E. No. 110 transmission oil. On the other hand, the same result might be sought by using 25 per cent of lead soap in a 60 at 210 U. S. oil. It is possible that the petroleum oil plays the larger part in fluid-film lubrication because of its viscosity and that a small quantity of lead soap is necessary only to complete the characteristics of a film capable of carrying 30,000-lb. loads on Mr. Wooler's test machine. This would explain the failure of some lead greases having a high soap-content.

Several authorities, including Dr. Herschel, have stated that oxidation of petroleum oils lowers the coefficient of friction. To chemically combine sulphur with petroleum oils we resort to oxidation, or perhaps vulcanization would better describe the action. It would be of interest to determine whether an oxidized oil without sulphur would act the same as the same oil combined with sulphur.

In commercial practice large quantities of sulphurized cutting-oils are used on production machinery. Mr. Beaver, engineer of tests for the National Cash Register Co., told me that the substitution of non-sulphur oils in his shop would reduce production by 25 per cent and run the tool costs up correspondingly. I have been unable to find an explanation for this phenomenon.

I hesitate to recommend the use of sulphur and sulphur compounds in automotive lubricants because of their corrosive action. Somewhere in our library is a very convincing article on the corrosive effects on wrist-pins of using oils containing sulphur, but we were unable to locate it in time to include the information in this discussion.

In conclusion, it would be of great interest to see the results of a series of tests on Mr. Wooler's equipment of the following:

> The maximum permissible load, the coefficient of friction and the maximum temperature using the following sample lubricants:
>
> (1) A steam-refined cylinder stock of 150 at 210 U. S. viscosity
>
> (2) The same oil with 8 per cent of fish oil added
>
> (3) No. (1) with 2 per cent of fish oil added and oxidized to the viscosity of a sample of No. (2)
>
> (4) No. (1) with 2 per cent of fish oil and 1 per cent of sulphur added and oxidized to the viscosity of No. (3)
>
> (5) Sample No. (3) with 8 per cent of lead soap added
>
> (6) Sample No. (4) with 8 per cent of lead soap added

Utilizing the Latent Heat of Cooling Water

1930 Transportation Meeting Paper

By Adrian Hughes, Jr.[1]

RESULTS obtained by the United Railways & Electric Co. of Baltimore from the application of a new type of cooling system to its motorcoaches are presented in the paper. This system, which utilizes the latent heat of vaporization to increase the heat-dissipating capacity of the cooling fluid and also varies that property in approximately direct proportion to the load on the engine, is of the closed type, employs the simple principles of low-pressure steam-powerplants and prevents boiling on the water-jacket side of the cylinder-walls. Its primary object is to permit engine operation at very high jacket-water temperatures, the water remaining liquid and circulating properly even though it may be above the boiling point at atmospheric pressure.

The equipment required to apply this system to the usual pump-driven circulating system consists of a temperature-control valve, a venturi tube with a nozzle of special construction, a condenser and a safety valve. The operation of the system is described and data on the results obtained in actual operation at Baltimore with the new system and the conventional vented system are presented, the text being supplemented by several charts. Tests made at Camp Holabird, Md., by engineers of the Motor Transport Corps are also discussed briefly and curves of results are included.

Application of the system to automotive equipment presents no great difficulties, in the opinion of the author, provided suitable equipment, especially radiators and pumps, are developed and made commercially available. The former will not be any more complicated and difficult to produce than the present type, and leaks will be eliminated, thus rendering the full benefits from the system available. Possible applications that are specifically mentioned include Diesel engines, for both stationary powerplants and locomotives, and airplane engines, but the system can be applied to all forms and uses of the internal-combustion engine.

THE advantage of steam or vapor-cooling for gasoline engines, permitting a higher jacket temperature and making use of the latent heat of vaporization of water or other cooling fluids, is well known and has been discussed a number of times in THE JOURNAL and in other technical papers. Many attempts have been made by prominent engineers of the automotive industry to obtain practical application of this improved method of cooling but, so far, without success.

In almost every discussion of internal-combustion engines from whatever angle they have been considered, whether that of engine design, fuel or lubrication, the importance of uniform and high temperatures is emphasized one way or another, which has been very interesting to note. Lubricating engineers, fuel producers and designers of automobile, Diesel and airplane engines are all asking for a means of obtaining these desirable temperature conditions, and the means is now at hand.

A practical method has been developed for increasing the capacity of a cooling fluid for heat dissipation by using the latent heat of vaporization, and, what is even more important, of varying the heat-dissipating capacity of the fluid approximately in direct proportion to the load on the engine. This system has been in use on motorcoaches of the United Railways & Electric Co. of Baltimore since 1926. Several years ago I wrote of the experiments that were then being made on our property and have been surprised that so little interest has been evinced in this most desirable advance in the cooling development for internal-combustion engines.

The new system, developed by Clinton R. Foutz, works so well in practical operation that the results are beyond anything automotive engineers and operators have heretofore thought possible. Users of internal-combustion engines can save one-tenth or more of the fuel, to say nothing of the important economies to be derived in engine maintenance through the elimination of engine failures resulting from a breakdown of the circulation of the water and failure to extract heat uniformly from the cylinder-walls under certain conditions with which motorcoach and motor-truck operators are so familiar. It is a closed system and employs the simple principles of the old low-pressure steam powerplants. The latent heat of vaporization is utilized in addition to the transfer of heat by the temperature change of the liquid, and yet ebullition, or boiling, on the water-jacket side of the cylinder-walls is prevented. It holds promise of bringing about a decided improvement in the cooling of internal-combustion engines with a corresponding improvement in thermal efficiency, more reliable operation under all load conditions and a reduction in cylinder and piston wear. Although decided advances in the design of engines have been made in the last 35 years, little or no real advance in the design of the cooling system has taken place. An increase of the thermal efficiency of the engine was impossible with the conventional type of cooling system, whether thermosiphon or water circulation by pump.

Some engineers may confuse the Foutz system with so-called steam-cooling because of its high-temperature

[1] M.S.A.E.—Superintendent of bus transportation, United Railways & Electric Co. of Baltimore.

operation, and this idea, associated with the complete failure of steam-cooling, would prevent them from realizing the value of the new system in heat dissipation. As is usual in the application of inventions and new developments, the only thing preventing the general use of the advantages of this system is its commercialization. Cooperation from the builders of engines, radiators and pumps would aid the users of internal-combustion engines in reaping its full benefits.

Advantages of High-Temperature Cooling

Pointing out the advantages of high-temperature cooling is not necessary. Engineers and scientists prominent in the industry have proved by experiments that it possesses decided advantages that will materialize in practice. Experiences in Baltimore and the City of Washington with this system have shown that these advantages do materialize. It is a subject of importance to designing engineers, engine manufacturers and operators. Such prominent engineers as H. L. Horning, A. G. Herreschoff and Herbert C. Harrison have had articles in THE JOURNAL in connection with their efforts to develop steam or evaporative cooling.

The idea that engines could be cooled by a simple evaporative process by using what might be called boiling systems prevailed for many years. Such systems were recorded in the art many years back in this and in foreign countries. The culmination of this attempt occurred during the years 1924, 1925 and 1926. Efforts to create a cooling system on the boiling-evaporative principle not only occupied the attention of many individuals and the research staffs of large corporations but was participated in by engineers of the Army and the Navy. The attempts at cooling by what may now be referred to historically as conventional boiling systems ended about Dec. 14, 1926, with the laboratory report of the Army Air Service.

A few references will be sufficient to show, first, what was attempted commercially, and, second, the universality of the opinion that high-temperature operation is necessary and desirable. Without high-temperature cooling, no type of internal-combustion engine can ever be operated satisfactorily from the standpoints of thermal efficiency, perfect combustion and mechanical maintenance.

An article entitled Steam Cooling[2], by Alexander Herreschoff, appeared in THE JOURNAL of October, 1925. Cylinder-Temperature Control by Evaporation[3], by the same author, appeared in THE JOURNAL of February, 1926. The summary preceding that article reads in part,

> . . . the author states that engines of the future will be steam-cooled and covered with an insulating jacket to prolong greatly the cooling-off time after the engine has stopped.

That was an interesting prediction in 1926. It has not been accomplished yet, but it can be accomplished now.

Other articles of interest are Evaporative Cooling[4], by Herbert C. Harrison, in THE JOURNAL of February, 1926; High Average Operating-Temperature and Engine and Car Operation[5], by Alex Taub and L. P. Saunders, in THE JOURNAL of March, 1926; and Thermo-Vapor Engine-Cooling Systems[6], by C. H. Kenneweg, in THE JOURNAL of September, 1926. These articles bring out very clearly the advantages obtainable from high-temperature cooling.

Recent references to liquid-cooled airplane engines also indicate the importance of this high-temperature cooling method. In the S.A.E. JOURNAL of October, 1930, an article on The Possibilities of Liquid-Cooled Aircraft Engines[7], by Rex B. Beisel, vice-president and chief engineer of the Spartan Aircraft Co., claims a number of advantages of liquid-cooled engines for airplanes, brings out the importance of obtaining high-temperature cooling and refers to the possibility of obtaining this with ethylene-glycol. Among other advantages, he cites a 20-per cent improvement in fuel economy in Wright field tests at a cooling-liquid temperature of 300 deg. fahr.

The use of a cooling liquid at a boiling temperature of 335 deg. fahr. does not assure an average operating temperature of 300 deg. fahr. nor does it prevent, under certain conditions, exceeding the boiling temperature with the resultant breakdown of the circulation of the liquid. The method of using the liquid must ensure circulation under all conditions and maintain a high average jacket-temperature. Even with such liquids this cooling system is still necessary to obtain the benefits of high-temperature cooling. Liquid-cooled engines for aircraft will then have the additional advantages of a substantial reduction in weight, an increase in economy and reliability, full-load operation for any length of time without fear of overheating and will be independent of temperature or altitude.

In the April, 1930, issue of *The Automobile Engineer*, A. J. Rowledge, in an article entitled Water-Cooled Aero Engines[8], states that:

> The next six years should see the general adoption of evaporative cooling, or, as it is generally termed, steam-cooling, with or without the general adoption of the use of a fluid other than pure water as the cooling medium. Enough experimental work has already been done to make the success of such a system quite certain, giving us at once complete automatic cylinder-temperature regulation and a lighter cooling system, containing less water, and the possibility of a cooling system without drag. This system is the answer to the reduction in resistance obtained recently on air-cooled engines by improved cowling. But the author feels that air-cooling can never be controllable and must always be rather overcooled if any margin of safety is to be attempted.
>
> At some future date automatic mixture-strength regulation with change of altitude will be universal. The problem is not easy but the development of a successful arrangement will be greatly helped by the possibility of uniform temperature for carburetion and cylinders, which water-cooling provides and which will be perfected when evaporative cooling has come into use.

Recent articles on fuel studies also indicate the value of uniform high temperatures. One of the most recent that has come to my attention and which brings out, incidentally, the effects of temperature, is a series of papers entitled Motor-Fuel Volatility[9] by Prof. George Granger Brown, Emory M. Skinner, Charles L. Nichols and Paul Bigby, of the University of Michigan, and in which reference is made to the Baltimore experiments with fuels and with the Foutz system as reported be-

[2] See THE JOURNAL, October, 1925, p. 327.
[3] See THE JOURNAL, February, 1926, p. 153.
[4] See THE JOURNAL, February, 1926, p. 195.
[5] See THE JOURNAL, March, 1926, p. 255.
[6] See THE JOURNAL, September, 1926, p. 295.
[7] See S.A.E. JOURNAL, October, 1930, p. 403.
[8] See *The Automobile Engineer*, April, 1930, p. 141.
[9] See *Industrial and Engineering Chemistry*, March, 1930, p. 278, and June, 1930, p. 649.

fore the Pennsylvania Section of the Society at Elizabeth, N. J., last autumn.[10]

Probably the greatest difficulty in the use of internal-combustion engines on moving vehicles is the wide variation in temperatures encountered. Temperatures should be kept high but within the limits of effective lubrication. The most desirable condition is a uniform high temperature, not only in degrees but in all parts of the engine. That is to say, an important feature of the cooling system is to keep the engine hot.

Operates at High Jacket-Water Temperatures

The primary object of the system is to operate the engine at very high jacket-water temperatures; in fact, the water may be above the boiling point at atmospheric pressure but remains liquid inside of the water-jacket. It does not boil and it circulates properly, thus providing the necessary heat dissipation from the cylinder-walls and absolutely preventing the engine from overheating. The circulation does not decrease at high temperature but increases. By balancing the circulating fluid by the pressure of its vapor, keeping it liquid and at a high predetermined temperature required for operation and utilizing a fundamental principle of the latent heat of vaporization, this system has a capacity for heat dissipation several times greater at a temperature of 220 deg. fahr. or more, than any vented system at 190 deg. fahr., assuming that the vented system could be operated at so high a temperature. Some of the advantages of this cooling system are that it

(1) Gives quicker warm-up of the cooling fluid when the engine is cold and establishes water-jacket temperatures at normal above 212 deg. fahr, in less than one-half the time at three-fourths maximum engine power

(2) Increases brake horsepower, demonstrable on dynamometer test under high-temperature conditions

(3) Increases fuel economy because of increase in mean effective pressure directly due to reduction of heat loss and gives resulting improved combustion

(4) Makes possible the successful economical use of alcohol at atmospheric temperatures of 50 deg. fahr. and below without loss, and at water-jacket terminal-temperatures up to about 196 deg. fahr.

(5) Insures against freezing by maintaining a constant, predetermined percentage of alcohol indefinitely without loss by evaporation or boiling away

(6) Reduces scale formation of lime and other alkaline deposits in radiator and on water-jacket walls to the minimum by eliminating vaporization and boiling away of the liquid, which prevents precipitation from concentration. Scale is a non-conductor of heat and deposits irregularly in water-jackets and also clogs up the radiator.

(7) Results in improved lubrication because of lessened dilution and uniform high working-temperature.

The conventional cooling-system that has been in use for many years on automotive equipment is far from satisfactory. It is most efficient in dissipating heat when the temperature of the cooling fluid is low; it is least efficient when, under heavy-load conditions, the temperature of the cooling fluid is high, and it breaks down completely before the cooling fluid has reached the atmospheric boiling-temperature. These conditions are well known to all users of automotive equipment and to other users of internal-combustion engines. The results are inefficiency, excessive wear and overheating.

An overheated engine is one in which some part fails to function normally. No matter how high the water-jacket temperature may be, an engine is not overheated until the oil is burned from the piston-rings and cylinder-walls. In the conventional system seizure may occur even though the jacket temperature may be considerably lower than the boiling point of water, 212 deg. fahr., when distortion occurs. Overheating, as ordinarily met with, is the direct result of unequal heat-dissipation from wetted surfaces of the combustion spaces, because of which some parts become hotter than others. In the conventional vented automobile cooling-system this overheating occurs before the water has reached its atmospheric boiling-point, because no pump can either lift or force water near this temperature, cavitation converting the water into steam and the water circulation practically ceasing when 180 deg. fahr. is reached in the suction pipe. As this occurs, the vented system breaks down and overheating results.

Simplicity of Necessary Equipment

For application to the usual pump-driven circulating system, the equipment required is surprisingly simple and consists of four principal parts. The first is a temperature-control valve adjustable to the desired temperature of operation; the second is a venturi tube with a nozzle of special construction; the third is a condenser, and the fourth is a safety blow-off valve set for about 5 lb. In addition to these principal parts, a water-level gage mounted on the dash of the motorcoach should be used, and, if desired, temperature-indicating instruments can also be installed.

The venturi tube is placed in the lower suction-hose connection from the bottom of the radiator with the nozzle facing the pump. The connections between the venturi tube and the bottom of the condenser and between the venturi tube and the pump are made with flexible hose, but a piece of brass pipe must be inserted in the latter connection because the vacuum condition that sometimes exists tends to collapse the hose. The condenser is connected between the nozzle of the venturi tube and the air space in the upper part of the radiator tank at a point as high as possible above the water level. The temperature-control valve is connected with the top of the radiator.

The radiator and water-circulating system must be entirely sealed against admission of air but under certain conditions may vent into the atmosphere; therefore, the radiator filler-cap must be supplied with a gasket to insure no leakage. Reducing the area of the radiator through which the circulating water passes from the water-jacket of the engine is also necessary because a very considerable cooling action is obtained by the condensation of water vapor in the condenser. The safety valve is connected from the air space above the water level in the radiator and is usually set for about 5-lb. pressure, corresponding to 230 deg. fahr.

Operation of the System

Fig. 1 is a diagram of the system showing the location of the various parts. When the engine is started, water is forced through the engine jacket and through

[10] See S.A.E. JOURNAL, January, 1930, p. 49.

the radiator inlet *a* to the upper radiator-tank *b*. There it divides into two columns, descending through the water legs *c* on each side of the condenser *d*, which occupies the central portion of the radiator, into the lower radiator water-tank *e* and through the suction connections *f* and *g* and the venturi tube *h* to the pump *i*.

A suction is created in the nozzle *j* which withdraws air contained in the system from the condenser *d* and the space above the water level in the radiator tank *b*. The air entering the condenser through the condenser inlet *k* is passed through the condenser through its lower tank *l* and connections *m* and *n* to the nozzle *j* from which it emerges. Water and air now flow through the pump *j*, where, by cavitation, they emulsify. This air-water emulsion may become so intimate that the proportion of entrained air may exceed 50 per cent of the water with a specific heat of about 0.62 compared with a specific heat of 1.00 for water. This lowering of the specific heat of the circulating fluid reduces the quantity of heat that will be carried away from the engine walls and aids in shortening the warming-up period.

As the fluid warms up, the air will be driven off until

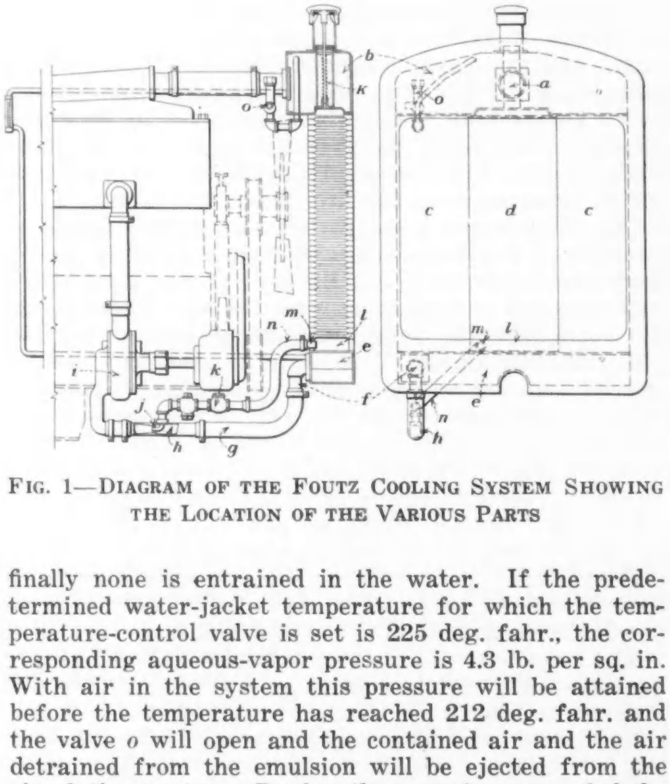


FIG. 1—DIAGRAM OF THE FOUTZ COOLING SYSTEM SHOWING THE LOCATION OF THE VARIOUS PARTS

finally none is entrained in the water. If the predetermined water-jacket temperature for which the temperature-control valve is set is 225 deg. fahr., the corresponding aqueous-vapor pressure is 4.3 lb. per sq. in. With air in the system this pressure will be attained before the temperature has reached 212 deg. fahr. and the valve *o* will open and the contained air and the air detrained from the emulsion will be ejected from the circulating system. During the warming-up period the condenser has not acted as a cooling factor except for the contained air.

This finishes the first or aerated stage and starts the second or deaerated stage of operation, or the circulation of water under its own saturated-vapor pressure. By deaeration, the boiling point of water is raised 58 deg. above its atmospheric boiling-point. When deaeration is complete, no air remains to occupy the space above the upper radiator-tank *b* and in the condenser *d*, and the latter now functions as a cooling factor. As the temperature of the circulating water increases, more and more vapor will be drawn into the condenser *d* and returned as cold condensate through the venturi nozzle, mixing with the warm water from the water legs *c* of the radiator, and then to the pump *i*. The enforced condensation thus created keeps the steam pressure from increasing by reducing the saturated-vapor volume to liquid. The non-return check valve *p* prevents the circulating water from entering the condenser when the engine is stopped.

The steam pressure produced in the upper radiator-tank *b* will force the water to the pump. The steam will exert pressure on the water and suction will no longer be required to draw the warm liquid to the pump. The mass flow of the cooling water will be increased or decreased in proportion to the vapor pressure existing above the surface of the liquid in the upper radiator-tank *b*. The rate of condensation becomes a function of the heat rejected to the jacket and the suction effect produced by the venturi tube.

Water is now being circulated in an altered physical state in which, first, its boiling point is raised and, second, its viscosity is lowered. Further, at high temperatures, the aqueous-vapor pressure above the surface not only prevents boiling by its presence but also balances the mass flow to the pump. Thus the liquid column in the pump-suction line is never broken, no matter how high the temperature of the water may become.

The static vacuum produced in the condenser by the venturi nozzle may vary from 2 or 3 in. of mercury to 20 in. or more. Vapor will be drawn from the surface of the water in the radiator and condensed in the condenser, thus invoking the latent heat of vaporization in dissipating excess heat from the engine. Cool water is returned to the pump as fast as it is formed in the condenser. For every pound of steam entering the condenser from the surface of the water from the radiator water-space, a pound of cold water is returned. Thus the quantity of vapor given off regulates the weight of water returned from both the condenser and the radiator, and an automatic auxiliary cooling-system is established, which, since nothing but steam can enter the condenser, assures rapid heat-dissipation at very high temperatures when the engine requires it and a greatly retarded dissipation of heat when the engine is below its normal high operating-temperature.

The value of this cooling system should be apparent from even this brief description of how it works and what it does, and proof of the results that will be obtained should not be necessary. However, abundant proof has been obtained even in the crude applications that have been made to the equipment available on the conventional cooling-systems. Obtaining the full benefits of the system from such applications is impossible and trouble from leaks will be encountered. The ordinary radiator built with lead solder was not designed to meet such conditions and will not stand up when vapor or steam is encountered under the pressures and temperatures used in this system.

This difficulty with radiators should be easy to overcome. All that is necessary is the developing of radiators of the correct design containing a large top tank to provide sufficient vapor space and a condenser strong enough to withstand the pressures that occur but otherwise very similar in appearance and construction to the present conventional radiator. Suitable radiators of correct design brazed with silver solder and tested for 60-lb. steam pressure will soon be available from one of the manufacturers of unit heaters. Then the full advantages of the system can be obtained and installations made. A water pump having the required characteristics should be developed and should have

packing glands that will prevent the loss of water under pressure conditions and leakage of air under vacuum conditions.

Results Obtained in Actual Service

The first installation of the system on a motorcoach was completed on Feb. 5, 1926, using a Model-50 White, with four-cylinder engine and 25-passenger city-type body. The system is now in use in Baltimore on nine Model-50 Whites, one Model-65 White and one A.C.F. and in the City of Washington on 15 Model-Z Yellow motorcoaches, with a total operation of more than 3,000,000 vehicle-miles.

Improvement in the operation of these motorcoaches is unquestionable. The results obtained are particularly satisfactory in power and in freedom from knocking. The reliability of the operation of the engine has been increased and the maintenance forces are seldom subjected to road calls because of engine trouble. A substantial reduction in shop labor has been effected through the almost complete elimination of carbon formation and a surprising reduction in the wear on cylinder-walls. The carbon is cleaned from engines equipped with the Foutz system about every 20,000 miles instead of 5000 miles, and even at the longer period the carbon formed is merely a soft soot that can be wiped off instead of the hard packed carbon usually found. The measurement of cylinder-wall wear in one

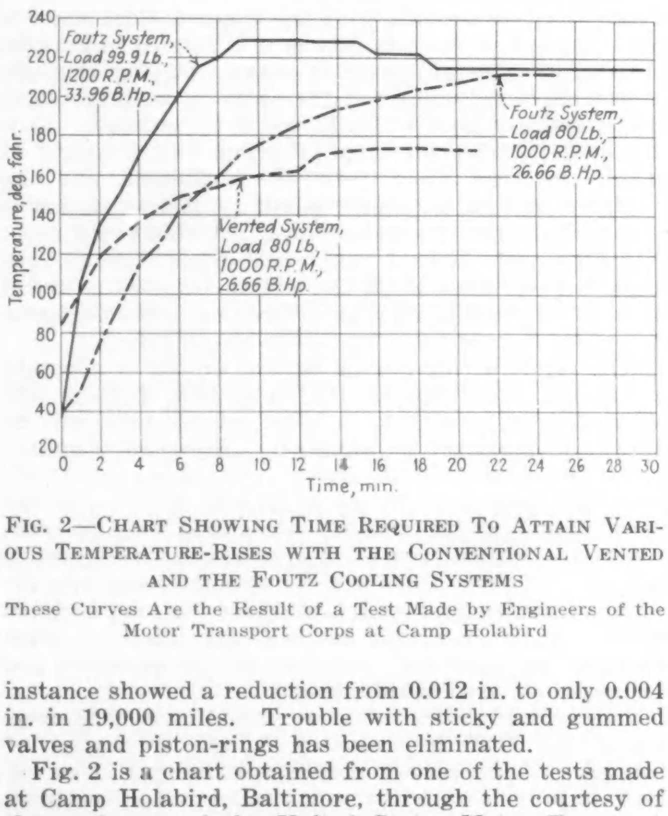


FIG. 2—CHART SHOWING TIME REQUIRED TO ATTAIN VARIOUS TEMPERATURE-RISES WITH THE CONVENTIONAL VENTED AND THE FOUTZ COOLING SYSTEMS

These Curves Are the Result of a Test Made by Engineers of the Motor Transport Corps at Camp Holabird

instance showed a reduction from 0.012 in. to only 0.004 in. in 19,000 miles. Trouble with sticky and gummed valves and piston-rings has been eliminated.

Fig. 2 is a chart obtained from one of the tests made at Camp Holabird, Baltimore, through the courtesy of the engineers of the United States Motor Transport Corps, and illustrates the difference in warming-up periods between the conventional and the Foutz systems. One of the curves shows the temperature rise for the conventional vented system at a constant load of 26.66 b.hp. at 1000 r.p.m. from an initial temperature of 85 deg. fahr. to the maximum of 177 deg. fahr., or a difference of 92 deg. fahr. in 16 min.

A temperature curve for the same engine, equipped

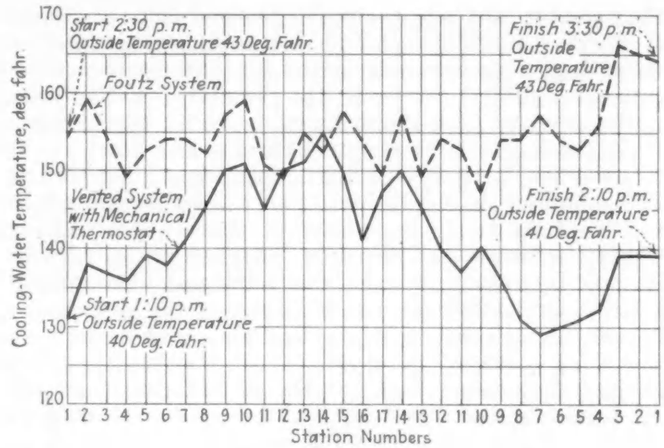


FIG. 3—COMPARISON OF COOLING-WATER TEMPERATURES IN TWO MOTORCOACHES

One Vehicle Was Equipped with the Conventional Vented Cooling System and a Mechanical Thermostat, and the Other Was Equipped with the Foutz Cooling System

with the Foutz system and operated at the same load of 26.66 b.hp., is reproduced. This shows a temperature rise of 92 deg. fahr. from 41 to 133 deg. in 5.5 min., and the maximum temperature of 212 deg. fahr. was reached in 22 min. A temperature curve for the same engine with the Foutz system at a constant load of 39.96 b.hp. shows a temperature rise of 92 deg. fahr. from 38 deg. to 130 deg. in 1.8 min. and to the maximum temperature of 228 deg. fahr. in 9 min.

Fig. 3 presents a comparison, at various points or stations on the Roland Park route in Baltimore, of temperatures between the two Model-65 19-passenger White motorcoaches, one equipped with the Foutz system and the other with the conventional vented system and mechanical thermostat. The latter shows considerable variation in temperature, with a minimum of 129 deg. fahr., a maximum of 155 deg. and an average of about 141 deg. The other vehicle shows a fairly constant temperature, with a minimum of 147 deg. fahr., a maximum of 166 deg. and an average of about 155 deg. This chart does not show the possibilities of the new system because the radiator was not designed with correct relations between the areas of the condenser and the water legs, but it does indicate the difference in the performance between the two systems.

The comparison of fuel economy on a Model-65 19-passenger White motorcoach on the Roland Park route is given in Fig. 4. The test was made primarily to try certain fuels but illustrates the increased economy that can be expected from the new system over the conventional cooling-system. The test started Nov. 1 and terminated Dec. 31, 1929. The Foutz system was installed on one motorcoach on Nov. 14. Up to that time this vehicle showed a lower average fuel-economy than the other vehicles of the fleet. From then on, however, it consistently showed a fuel economy substantially greater than the rest of the fleet. These motorcoaches average 2850 miles each per month, or a total for the seven over a two-month period of 39,893 miles.

Fig. 5 shows a series of curves from another test made by Motor Transport Corps engineers at Camp Holabird. The two friction-horsepower curves show the difference in power necessary to turn the engine over with an electric motor at speeds varying from 400 to 2000 r.p.m., in one case with a water-jacket tem-

perature of about 57 deg. fahr. and in the other with a temperature of 222 deg. fahr. at the beginning of the test and about 180 deg. at the end of the test. At 2000 r.p.m. the friction horsepower was 12.9 b.hp. less with the warm engine than with the cool one and indicates the saving possible through quick warm-up and operation at high temperatures.

The most interesting curves are the water-jacket outlet and inlet temperature-curves. The data for these curves were obtained simultaneously with the data for the brake horsepower, torque and economy curves and show the surprising results that are obtained with this system for internal-combustion engine-cooling. The outlet temperature was about 212 deg. fahr. for virtually the entire run, but, as the load and the speed increased, the water-jacket inlet-temperature actually decreased from 180 deg. fahr. at 400 r.p.m. and 13.8 b.hp. to 131 deg. at 1800 r.p.m. and 52.2 b.hp.

The effects obtained from the Foutz system are diametrically opposite to those with the conventional vented cooling-system and may seem complex but are really very simple. Further consideration might be desirable of the reason why these simple mechanical devices establish the means by which water at high temperature can be circulated continuously in the liquid state with automatically controlled mass flow and with a cooling effect proportional to the heat rejected to the circulating water when the engine is warm and how a quick warm-up is effected when the engine is cold.

Pressures are equal in all directions in a sealed system, but this applies only to fluid at rest, for when in motion pressures vary and are not the same at all points. To prevent confusion we must keep in mind the fact that in the new system pressures in the moving fluid vary at different points and their effect on flow may be either positive, acting in the direction of the flow, or negative, acting against the direction of flow.

In one of these tests made by engineers of the Motor Transport Corps at Camp Holabird on the Government

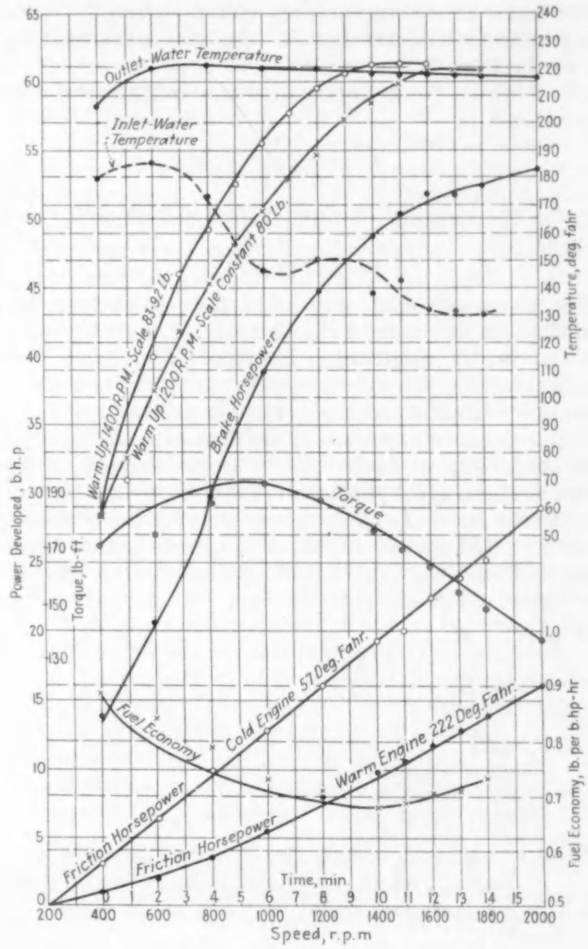


FIG. 5—TEMPERATURE, HORSEPOWER AND FUEL-ECONOMY CURVES OF A WHITE 4¼ X 5¾-IN. MOTORCOACH ENGINE EQUIPPED WITH THE NEW COOLING SYSTEM

These Curves Were Obtained from a Test That Was Run on the Camp Holabird Dynamometer by Motor Transport Corps Engineers. Interesting Points about the Curves Are the Maintenance of a Water-Jacket Outlet-Temperature in Excess of 212 Deg. Fahr. for Virtually the Entire Run and the Decreased Inlet-Temperature as the Load and Speed Increased

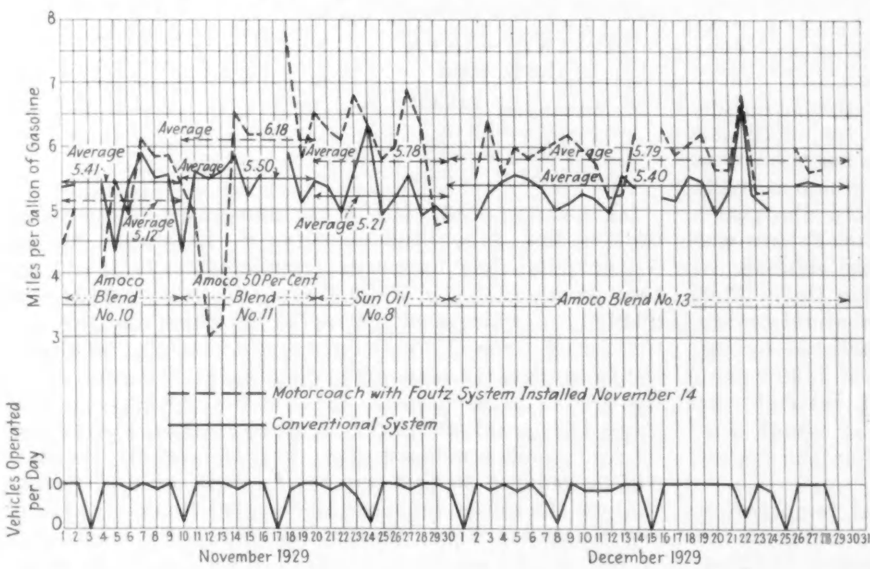


FIG. 4—COMPARISON OF FUEL ECONOMY OBTAINED WITH THE TWO COOLING SYSTEMS

The Test Was Run from Nov. 1 to Dec. 31, 1929, on a Fleet of Seven Motorcoaches. Six of These Used the Conventional Vented System throughout the Entire Period. The Seventh Vehicle Used the Conventional System for the First 14 Days and Its Average Fuel-Economy Was Lower than That of the Other Vehicles of the Fleet. Installing the Foutz System Resulted in a Fuel Economy That Was Consistently Much Better than That of the Other Vehicles

dynamometer, actual flow conditions in the two systems were compared. The engineers ascertained that, when the engine was started and operated at a speed of only 1200 r.p.m., with cold water in the radiator, 70 deg. fahr. in the conventional system and 60 deg. in the Foutz system, the pump produced a vacuum of 1.3 in. of mercury in the pump-suction pipe with the conventional system, and a pressure of 1.0 in. of mercury was immediately established and maintained with the Foutz system, increasing with the temperature before deaeration occurred and condensate formed in the condenser. The pressures were determined by balancing the U mercury columns against the hydro-

static head of water in each system when at rest. A diagrammatic illustration of the test arrangement is shown in Fig. 6.

The formula for quantity of water in gallons delivered per second is

$$Q_c = A \times v_c/231 \qquad (1)$$
$$Q_f = A \times v_f/231 \qquad (2)$$

and for the velocity of flow in feet per second the formula is

$$v = \sqrt{(2\,gH)} \qquad (3)$$

The cross-sectional area A of the outlet may be assumed to be the same in both systems, and the divisor, 231 cu. in., is identical. Therefore the mass flow is proportional to the speed or velocity of flow in the suction pipe through the cross-sectional area.

Using the known values as determined, the velocity of flow occurring in each system is as follows. In the Foutz system, the hydrostatic head H_f was 1.50 ft. and the suction head H_p was a pressure of 1 in. of mercury, equal to 1.137 ft. of water; that is, it had a negative value and was working against the direction of flow of the water. The total head

$$\begin{aligned} H &= H_f + H_p \\ &= 1.500 \text{ ft.} - 1.137 \text{ ft.} \\ &= 0.363 \text{ ft.} \end{aligned}$$

Hence

$$\begin{aligned} v_f &= \sqrt{2gH} \\ &= 8.02 \times \sqrt{0.363} \text{ ft.} \\ &= 8.02 \times 0.603 \text{ ft.} \\ &= 4.84 \text{ ft. per sec.} \end{aligned}$$

In the conventional system the hydrostatic head H_c was 1.5 ft. of water, and H_s, the suction head, was a suction of 1.3 in. of mercury, equal to 1.478 ft. of water. The total head

$$\begin{aligned} H &= H_c + H_s \\ &= 1.500 \text{ ft.} + 1.478 \text{ ft.} \\ &= 2.978 \text{ ft.} \end{aligned}$$

Hence

$$\begin{aligned} v_c &= 8.02 \times \sqrt{2.978} \text{ ft.} \\ &= 8.02 \times 1.724 \text{ ft.} \\ &= 13.51 \text{ ft. per sec.} \end{aligned}$$

In the former system, while the indicated velocity due to the positive pressure is 4.84 ft. per sec., it is not exactly this much. A correction factor must be used to allow for the volume of air entering, which actually reduces the volume of water discharged by the pump. Just what is the value of this correction factor was not determined, and it would depend upon relative capacity of the discharge nozzle and suction line. That the volume of water flowing to the pump would be less under these circumstances than that indicated by the velocity is apparent. At an engine speed of 1200 r.p.m., therefore, the volume of water forced through the engine jacket with the Foutz system is about one-third that in the conventional system when the engine is cold.

With the engine warmed up to normal temperature and operating at maximum speed and load and with the Foutz cooling-system deaerated, the condition of flow is very different. No parallel for this condition exists in the conventional system because it ceases to circulate water at about 180 deg. fahr. After the air is eliminated from the Foutz system, the pressure effect at H_p changes from a negative force, acting against, to a positive force acting in the direction of flow. This is very evident, for the vapor above the water surface in the radiator cannot pass through the condenser except as condensate, and the volume of the cold liquid is too small to affect the pressure. So the pressure at H_p now has become 0 lb. per sq. in. gage pressure. Thus, as the vapor pressure increases, the velocity increases.

With the engine operating at 225 deg. fahr. jacket-water outlet-temperature and 200 deg. fahr. radiator-outlet temperature, the hydrostatic head will be as before, $H_f = 1.5$ ft., and the pressure acting on the surface of the water in the top of the radiator will be that

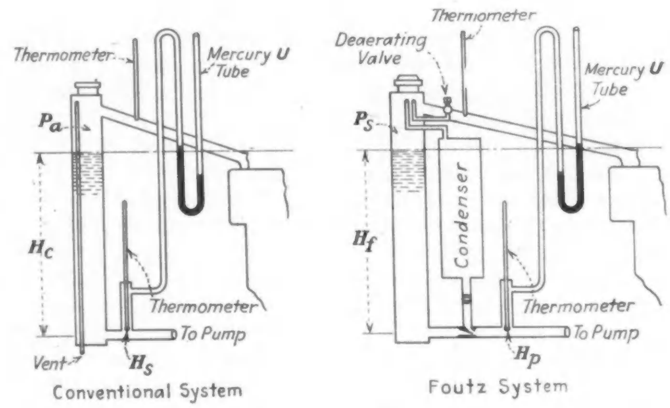


FIG. 6—ARRANGEMENT OF APPARATUS FOR COMPARING FLOW CONDITIONS IN THE CONVENTIONAL AND FOUTZ COOLING SYSTEMS

This Test Was also Made at Camp Holabird

corresponding to the aqueous-vapor pressure of water at 225 deg. fahr., which is 19 lb. per sq. in., absolute, or 4.3 lb. per sq. in. gage. The latter is equivalent to 10.3 ft. of water at 200 deg. fahr. At 225 deg. fahr. jacket-water outlet-temperature and 200 deg. fahr. radiator-outlet temperature, the total head H causing flow to the pump is, as before, the hydrostatic head H_f and the steam pressure P_s, or

$$\begin{aligned} H &= 1.5 \text{ ft.} + 10.3 \text{ ft.} \\ &= 11.8 \text{ ft. total} \end{aligned}$$

for which the velocity is

$$\begin{aligned} v &= 8.02\sqrt{11.8} \text{ ft.} \\ &= 8.02 \times 3.43 \text{ ft.} \\ &= 27.51 \text{ ft. per sec.} \end{aligned}$$

This shows that, with a radiator-outlet temperature of 200 deg. fahr., the velocity of the water flowing to the pump has increased from 4.84 to 27.51 ft. per sec., or an increase of 22.67 ft. In other words, the quantity of water now passing to the pump and through the jacket around the heated cylinder-walls is almost six times greater than when the engine was cold, as in the first or aerated state. Should the variation in load cause the jacket-outlet temperature to drop to 212 deg. fahr., P_s will become 0 gage, and the velocity of flow will be reduced to that due to H_f alone, or 9.77 ft. per sec. If the outlet temperature be still further reduced, say to 180 deg. fahr., then P_s becomes sub-atmospheric, or 7.51 lb. per sq. in., absolute, a total change in vapor pressure of 11.49 lb. per sq. in., absolute. From this it is very apparent that not only has the velocity of water flow greatly decreased but also the flow of steam into the condenser. It is now clear how cooling in the Foutz system takes place and also how the vapor pressure automatically controls and makes the rate of cooling proportional to the heat rejected to the jacket by the

engine. The values used are for purposes of illustration only and are approximate.

Friction is an important factor, affecting the flow in both systems, but with different results, being beneficial to the Foutz system and detrimental to the conventional system. Friction resistance retards the mass flow and in the former system helps to shorten the warming-up period. In the latter system it reduces the pressure in the suction line, increasing the cavitation and assuring a quicker breakdown of the water flow in the pump-suction line.

Little attempt has been made to go into all of the details of the theory of this new system. Sufficient information has been presented to prove that it works in practice and gives the results that would be expected theoretically. On a comparatively small motorcoach operation no opportunity for exact laboratory experimenting exists, and very fortunately the testing facilities at Camp Holabird were available. The engineers of the Motor Transport Corps have been most accommodating, making tests and providing data, to some of which reference has been made.

Application of the Foutz System

That no great difficulty in the way of the application of the Foutz system exists should be clear. Suitable materials, particularly radiators and pumps, must be developed and made commercially available. The new radiator will be no more complicated and difficult to produce than the present types. Then the full benefits from the system can be obtained without being inconvenienced by leaks that now occur. Since a somewhat higher grade of material is needed with this system than with the conventional one, a somewhat higher cost for the cooling system than is now the case might result, but with widespread use so that these materials are in production, such increase will be a very small fraction of the total cost of equipment. With the present necessity of obtaining special material, the cost will be somewhat greater but, even under this condition, it will without question pay for itself many times over.

Among some of the attempts to improve the cooling of internal-combustion engines have been experiments with liquids of higher boiling-temperatures than water, but I am not very familiar with these experiments. Such liquids might tend to raise the average temperature of the water-jacket but, if used with the conventional system, many of the same objections as at present would arise, since the capacity for dissipating heat would vary inversely with the load on the engine instead of proportionately to it, as in the Foutz system. Also, to provide for the occasional heavy-load conditions, radiator capacity would have to be provided which would be excessive under average conditions.

While this paper deals primarily with the application of the Foutz system to automotive equipment, it is applicable to all forms and uses of the internal-combustion engine. In fact, it might prove of even greater importance to the Diesel engine, both for stationary powerplants and for locomotion purposes, than to the present gasoline automotive engine. I have no doubt that it would decrease many of the present difficulties and that an increase in the application of these engines would be brought about. Diesel engines have been coming in for considerable discussion recently. The S.A.E. JOURNAL for September, 1930, contained two articles on Diesel engines, one by H. D. Hill[11]; the other by C. L. Cummins[12]. A high constant temperature in Diesel engines is perhaps more important than in the gasoline engine because the former is essentially a heat engine. In the S.A.E. JOURNAL for May, 1930, O. D. Treiber mentions the difficulty of complete combustion in the cylinder as liquid fuel comes in contact with cool cylinder-walls in the small-size Diesel engine.[13]

A great number of the difficulties encountered in the efforts to develop small Diesel engines can be overcome by constant and high water-jacket temperatures. The Foutz cooling system will help considerably in the development of Diesel engines but will not necessarily give it preeminence over the gasoline engine, because at the same time it will bring about improvements in the latter. The gasoline engine will not only increase in efficiency but it can burn cheaper fuels, higher end-point gasolines, or even certain grades of fuel oil. In a recent trial at Baltimore with the Godward vaporizer on a Model-508 A.C.F. motorcoach, with a Hall-Scott engine, a run of 30.4 miles was made with the conventional cooling-system, using 6.9 gal. of fuel oil, or 4.47 miles per gal. The same motorcoach with the Foutz cooling-system made a run of 34 miles and required 5.5 gal. of fuel oil, or 6.18 miles per gal., an improvement of 38 per cent. Vaporizing the fuel thoroughly before it goes into the cylinder is not sufficient. The cylinder must be warm enough to keep that fuel vaporized if it contains heavy ends. With the conventional cooling-system in this test, the jacket-outlet temperature averaged about 131 deg. fahr., and with the Foutz cooling-system, it averaged 228 deg. fahr.

The airplane engine may present another field in which this system will be most welcome and of great assistance. The quantity of water required will be greatly reduced, the danger of loss of water with properly constructed materials is very slight, and the uniform temperatures under all conditions will be most helpful. The recent attempt to cross the Pacific from the west, which came so near to resulting disastrously, could have been successfully made with this system in use. I recommend its careful consideration by those interested in this form of transportation.

The limited application of the system in Baltimore has proved its worth and I hope that in the near future, with suitable materials available, I can report its successful application to all of our equipment. Difficulty that is now being experienced with otherwise entirely satisfactory new equipment could be entirely eliminated by the use of this system.

THE DISCUSSION

J. A. HARVEY[14]:—Did you have any trouble with the oil due to the higher temperatures during your tests? Did you have to use a special oil, or was the ordinary engine-oil that is available today satisfactory?

ADRIAN HUGHES, JR.:—The oil temperatures are not any higher than we have now. The oil troubles are very much lessened because virtually no dilution occurs. Quick warm-up practically eliminates dilution of oils;

[11] See S.A.E. JOURNAL, September, 1930, p. 282.

[12] See S.A.E. JOURNAL, September, 1930, p. 285.

[13] See S.A.E. JOURNAL, May, 1930, p. 581.

[14] M.S.A.E.—Operating engineer, Pittsburgh Motor Coach Co., Pittsburgh.

in fact, lubrication would benefit very materially by the constant temperature. Within reasonable limits, how high the temperature is does not make any difference, as the lubrication engineers can design the oil for such temperature.

Operating Temperature Is Important

C. M. BILLINGS[15]:—From the viewpoint of the lubrication engineer, the question of temperatures is very important. I agree with Mr. Hughes regarding the importance of high operating-temperatures. One of the worst things that we have to contend with, as regards lubrication, is the cold-running engine. Not alone does it give inferior performance from the operator's standpoint, but it has considerable influence on the maintenance cost. With gasoline having a 420-deg. endpoint today, engines must be operated at higher temperatures than formerly to burn the heavy ends clean. If the heavy fractions are not completely burned, they find their way to the oil sump, washing off the oil film between the piston and the cylinder walls, and, when the engine starts up under load, we have practically metal-to-metal contact. In general, the operating temperature should be anywhere from 180 to 200 deg. fahr. for efficient operation.

The worst offenders as regards dilution are salesmen and physicians operating cars in the winter with frequent stops and starts and consequent excessive use of the choke. We have found cases where 35 per cent of the crankcase contents was raw fuel. You can readily see what our problem is when oil is diluted to that extent, and the wear that is caused by the greatly thinned oil-film between the piston and the cylinder-walls and in the bearings.

B. B. MEARS[16]:—Would not the higher temperatures aggravate the permeation of the interior of the motorcoach by crankcase-oil and exhaust-gas fumes?

MR. HUGHES:—I think that could be answered better by the engine designer, but the high temperature, bringing about more complete combustion, would tend to decrease rather than increase the gases. I would not imagine it would have a noticeable effect.

J. F. WINCHESTER[17]:—Mr. Hughes, in discussing the possibility of steam-cooling, cited a number of authors who presented material in 1926 and predicted then that in a short time virtually all types of automobile equipment would be steam-cooled. At the time that this discussion was going on, I was inclined to believe that the development would be rapid, but I have never been able to find why it dropped by the wayside. Certainly considerable money and effort were expended at that time on steam-cooling. Yet today we have practically nothing of that kind in current production.

I wonder just what relation this type of cooling has to the operating of fuel and would like to have the phenomenon explained as to why knocking is eliminated; also perhaps some of us who do not study the results carefully might be a little confused since in some parts of Mr. Hughes' paper he shows curves and mentions the possibilities of running at temperatures that are considerably above the nominal temperature of boiling water but in later curves shows that the experimental temperature at which these vehicles are operating is no greater than in many other types of standard equipment we are operating. For that reason I wonder whether the expensive type of installation as advocated would be justified when compared with the simple thermostat located in the radiator water-inlet pipe. Has Mr. Hughes any data to show that this type of thermostat does not maintain the temperatures at approximately the same point as shown by the Foutz system in Fig. 3?

Use of Blended Fuels

In addition to that, I noted that in Fig. 4, where he shows the results obtained in the different types of motorcoach, the type of fuel used was a benzol blend. Since Baltimore is a center of benzol blends and considerable quantities of them are being sold there, because of their low knock-rating at a premium of 3 cents per gal., I wonder how he is able to determine the difference in the knock-rating results obtained in the test machine; also, where a constant temperature of this kind is used, would not using a much lower grade of fuel be practicable instead of experimenting, or perhaps showing comparative results with a high-grade premium fuel? To my mind, higher temperatures promote the opportunity for using fuels that cost considerably less than benzol blends.

MR. HUGHES:—I am very glad that Mr. Winchester brought up the question about the thermostatic control of shutters. I meant to mention it myself. Shutters on the car are an advantage but do not prevent frequent breakdowns of circulation in the conventional system. The Foutz system does not break down at all. As I pointed out in the paper, the reason we did not install more of them is that we are using the conventional type of radiator, which will not stand up in the presence of steam. We are, therefore, maintaining at present a higher average temperature, 200 deg., than we would get in the conventional system, but not as high as we can and will get with the radiators we are trying to obtain. The equipment required for this system is not complicated and should not be very expensive. It is merely a better radiator that will stand 60-lb. steam-pressure test.

I shall not attempt to discuss the point about knock rating. We have used blends in Baltimore, and some of the tests happen to have been made with blends. I merely brought out the incidental better economy with the Foutz system. We are now, and have been for some time, operating on straight gasoline. We found that we can get much better power from a higher end-point gasoline, 425 deg. or even higher. This system makes possible the use of the higher end-point gasoline and burning it efficiently and completely, which is a desirable feature.

MR. WINCHESTER:—One thing that might be a little misleading in connection perhaps with the operation of an average fleet of vehicles is that, while certain curves show a temperature of 220 deg., others show a nominal operating temperature of 167 deg. I am inclined to believe from my experience that when we get the right type of radiator and raise the temperatures to the point Mr. Hughes hopes to obtain, he will find that with the conventional type of engine he will have to go through almost the entire mechanism and change the clearances of the piston and the various parts to withstand the high temperatures under which he is operating. I am also inclined to believe that, where the experiments were conducted by an operating man, they might result in high upkeep cost, extending

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[16] M.S.A.E.—Lubricating engineer, H. L. Doherty & Co., New York City.

[17] M.S.A.E.—Superintendent of motor vehicles, Standard Oil Co. of New Jersey, Newark.

over a period of a year or two until proper clearances were established for the engine.

MR. HUGHES:—I think those questions are fully answered in the previous articles to which I referred. I do not believe that the use of the Foutz system will require any changes in engine design or in clearances other than those that will be found desirable to obtain greater benefits from the use of this system than might be possible with the present-day engines.

Effect of High Operating-Temperature Is Good

MR. BILLINGS:—I think that high operating-temperatures are essential for efficient engine-operation and are conducive to longer life of parts. Some time ago I investigated a case of piston seizure and cylinder scoring in a reconditioned engine being run on the dynamometer. I found that the water-outlet temperature was approximately 100 deg. fahr., and all we did to eliminate the trouble was to regulate the water-outlet temperature to 180 deg. fahr. The pistons were expanding, due to the heat of combustion, much faster than the cool cylinder-walls and seizing. Raising the cylinder temperature kept the clearance more constant and eliminated the trouble.

MR. WINCHESTER:—We are dealing here with temperatures that are entirely out of the range that the last speaker mentions. He is speaking of an engine that has been designed to operate at a temperature of 212 deg. and on the test block runs at 100 deg. When we raise the temperatures 160 deg., we get better operating conditions. I wonder what will happen when we take an engine that is designed to operate at 212 deg. and raise the temperature to 240 or 250 deg. We all know that the minute we begin running with boiling water today and have an overheated engine we certainly have very adverse operating conditions and encounter costly service problems. This might be brought about through the expansion and contraction of the metal. I am inclined to believe that perhaps this is a problem for the designing engineer rather than the operating man.

MR. HUGHES:—Mr. Winchester's point about running into overheating is a very different thing from boiling in the radiator. We should remember that this system is not steam-cooling but merely a water-cooling system taking advantage of the latent heat. The liquid water is kept flowing past the cylinder-walls all the time. The temperature desired is merely a matter of calculating, designing and building the correct relation between the condenser size and the water legs to get any temperature we may want and keep it constant. The important thing is to get a constant temperature for every part.

Conventional Radiator Unsuited to System

L. C. JOSEPHS, JR.[18]:—I believe that this system had originally two pumps, and the idea was to maintain constantly a temperature that would not exceed 190 deg., the object being to use a true vapor-cooling system. From that viewpoint it looked like a very good thing. Now we are going right back where the steam-cooling people were, getting temperatures of 240 or 250 deg. and redesigning the engines. Decreased volumetric efficiency, distortion in the cylinder-block and loss of power will come with higher temperature. If the temperature is kept down to 190 deg. we can use a standardized radiator.

Originally the temperature control of the system was somewhat similar to the Warren Webster heating system used in vapor-heating. Is that the type of valve which is now used?

MR. HUGHES:—The valve used is merely a blow-off valve that is operated by pressure.

The Foutz system never used two pumps and evidently is not the one referred to.

We can design this system to give a temperature of 190 deg. fahr. The advantage would be that we would always get 190 deg. and never get boiling or a breakdown in the circulation of the water, which is the case in the conventional system under variation of load. But even at 190 deg. the conventional radiator would not be satisfactory because we would have water vapor, and this radiator deteriorates very rapidly in the presence of steam or water vapor.

JOSEPH HUSSON[19]:—What would happen in the system if alcohol or Prestone were used?

MR. HUGHES:—The system can be operated with pure alcohol or alcohol and water and we would never lose the alcohol. With Prestone we would get approximately the same result. We get 200 or 300 deg. or any temperature whatever with alcohol or Prestone.

M. C. HORINE[20]:—Why does not the valve blow off all the time?

MR. HUGHES:—The condenser keeps down the vapor pressure. The valve is set for the vapor pressure existing at the operating temperature for which the system is designed. For instance, at an operating temperature of 225 deg., the vapor pressure is 4.3 lb. and we set the valve for about 5 lb. Then the system will blow off with air in the system, but after that the pressure will be kept down by the condenser.

Rapid Transfer of Heat Necessary

MR. HORINE:—At the high temperatures that you are proposing, will not the combustion-chamber temperatures also be so high as to tend toward knocking? The limit on compression is how fast we can dissipate the heat to prevent points of incandescence on the combustion-chamber area. Unless the higher temperature of the water, as it passes off, is accompanied by a higher rate of heat transference from the combustion-chamber to the water, I do not see how you can avoid the necessity of using considerably lower compression-ratios at those high temperatures.

MR. HUGHES:—That is exactly the point. The more heat that is given off, the faster is the rate of flow of water through the jacket compared with the heat to be dissipated, because the vapor would be formed faster, and vapor pressure would increase the flow of water, so more and more heat is carried off as it is formed.

MORSE W. REW[21]:—Has any appreciable improvement in the so-called gas-fumes situation resulted, and is more complete combustion secured?

MR. HUGHES:—We have not paid any particular attention to the odor of the gas fumes. More complete combustion of fuel in the cylinders will, of course, be obtained.

MR. WINCHESTER:—Four or five years ago our company conducted a number of experiments with liquids that had boiling-points of 240 deg. fahr. I do not know what relation that would have to steam-cooling, but we

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[19] Transportation engineer, Vacuum Oil Co., New York City.

[20] M.S.A.E.—Sales promotion manager, International Motor Co., Long Island City, N. Y.

[21] Superintendent of motorcoach department, Cleveland Railway Co., Cleveland.

do know that, when we used liquids having boiling-points of 240, 250 and 260 deg., we had a sticking engine that would not perform very satisfactorily. That is why we discontinued the experiments we were conducting. You may have run these engines at 240 or 260 deg. I should like to hear about some of the results you obtained when running at those temperatures.

MR. HUGHES:—The only runs made at the higher temperatures were by the United States engineers. They seem very well satisfied that the system is satisfactory and desirable.

The value of the high-temperature system was shown by the engineers who, some years ago, tried to use the steam-cooling system to obtain the higher temperature. They brought out the advantages of operating internal-combustion engines at higher temperatures. I am not an engine designer and cannot very well discuss this point.

MR. JOSEPHS:—That is the very reason why steam-cooling has not come into use. Its proponents promised that the engines would work at those high temperatures. Actually, I think every engine manufacturer experimented and found, among other things, that re-designing the engines and making many changes would be necessary before the system could be used.

MR. HUGHES:—These experiments seem to show that the results of the high temperature were very satisfactory. In the Wright Field tests on airplanes with temperatures of 300 deg., very great improvements were shown. Early efforts at steam-cooling were abandoned because it could not keep up the circulation of water. The system did not have this simple scheme of getting cold water to the pump and that was the reason it was abandoned. Mr. Foutz happened to hit on a way of keeping up the circulation of water under all conditions.

T. S. KEMBLE[22]:—One point brought out in this paper is possibly a partial answer to the question about the knocking tendency. I believe the author stated that carbon formation was greatly reduced if not entirely eliminated. In this particular case the reduction of the carbon formation might more than offset the increased average temperature of the combustion-chamber walls.

An additional point that has been brought out by inference anyway, is that with this system hot-spots are avoided. In one particular design we may be able to go to 190 deg. and in another to 212 deg.

From my experience with engines I do not believe that we could use this system for all engines at a temperature of 240 deg. Undoubtedly, redesigning would be required. Some of the engines might be entirely satisfactory for 240 deg. and others would require lower temperatures. The volumetric efficiency would be decreased. The other factors may more than make up for that decrease in volumetric efficiency within certain temperature limits.

Joints and Connections Must Be Kept Tight

A. H. GOSSARD[23]:—Mr. Hughes has said that this is a closed system and I would assume that it depends for its success upon all joints and connections being kept tight. Just what has been his experience in keeping all connections and joints in such a system tight on an automotive vehicle? That is extremely difficult and is the main objection to this method of cooling.

MR. HUGHES:—We have obtained fairly good results in keeping the system tight, even with the conventional radiator, but the trouble we have experienced is caused by the presence of steam in the lead-soldered radiator. In a radiator built for and tested at 60-lb. steam pressure, no difficulty would be encountered.

We have made enough tests and experiments with this system to convince us that it will do what it is intended to do. Of course, in a small motorcoach operation we are not in a position to make complete tests or to make laboratory tests. I should like to see that done by those in position to do it. But we have shown that the heat-dissipating system will give whatever constant temperature we want to design for and that it is independent of variation in load, temperature or altitude. That is important. A system of that sort can operate at a constant temperature with any load we want to put on the system and under any temperature condition.

MR. GOSSARD:—The tendency, particularly with motorcoaches, seems to be to use the latent heat in the water system for heating. Some day we may go even farther and that latent heat may be used for cooling the vehicle in the summer.

J. W. COTTRELL[24]:—Is steam ever discharged from the system when the engine has stopped at the end of a long run?

MR. HUGHES:—If, after a long run or a pull up a long hill, the vehicle were quickly brought to a complete stop and the engine idles, a sudden formation of steam in the water-jacket would occur, causing a rise in pressure which would open the deaerating valve and some vapor would pass out. However, the water would continue to circulate, although more slowly, and the system would soon return to normal. Even this slight loss of vapor could be avoided by running the engine at about half speed after the motorcoach has been stopped and gradually slowing the engine down. Of course, with the conventional system under that same condition boiling with a complete cessation of the circulation of water would immediately result and the condition would not return to normal until sufficient steam had passed out of the vent to dissipate all the heat stored in the engine, resulting in the loss of a large part of the liquid. In the Foutz system, only a small quantity of vapor is lost through the pressure valve because the water circulation does not break down and also the condenser continues to function.

[22] M.S.A.E.—Consulting engineer, Chicago.

[23] M.S.A.E.—Manager of automotive department, Middle West Utilities Co., Chicago.

[24] M.S.A.E.—Technical editor, *Commercial Car Journal*, Philadelphia.

Weight Saving by Structural Efficiency

By Charles Ward Hall [1]

18th National Aeronautic Meeting Paper

METHODS employed by the author to reduce the weight of the structural frame without sacrificing strength are described in the paper. To obtain this result the best available cross-section must be selected and the members arranged to transmit the load directly to the final supports which should lie approximately in a plane that is parallel to the load vector; also where a bending moment is caused by the loading, the support attachment should produce a moment of the same amount and of opposite sign. Avoiding secondary bending and utilizing the advantages of full continuity over supports can be secured by a simple arrangement of the frame members.

Substitution of power tools for hand tools will effect a reduction in assembly costs. Sections suitable for power assembly include closed hollow-sections, which have a high structural efficiency, as well as angles, channels, I-beams and similar shapes. These shapes and the riveting machines employed to assemble them are briefly described and illustrated, and some applications to flying-boat construction shown.

A weight of 1.10 lb. per sq. ft. for a tapered wing-section with a duralumin frame and a fabric covering, as contrasted with 1.75 lb. for metal-covered wings, was possible, according to one discusser. Beryllium alloys, while interesting from a laboratory viewpoint, are handicapped by high cost was the author's answer to another question. Stainless steel could be only one-third as thick as duralumin for the same weight or reinforcements must be spaced three times as closely. Another speaker said that very thin Bakelite fastened directly to the wood stringers of a flying-boat hull with countersunk screws enabled the boat to slide through the water easily because of its slipperiness, and since this material does not corrode, applications of protective paint are unnecessary.

THE structural design of aircraft may be conveniently divided into two general parts: the determination of the loading conditions and the design of a structure to sustain these loads. I do not propose to discuss the first of these divisions but, upon the assumption that a satisfactory specification for each condition of flight or landing is available, to proceed directly to a discussion of some of the availabel methods of building a structure to sustain these loads with the minimum expenditure of weight.

CHARLES WARD HALL

From one point of view—the pay load, that is, the weight which is to be transported, whether it be mail or other goods, bombs or machine-gun bullets—represents the only profitable part of the enterprise. A minimum weight of airplane structure, a minimum weight of powerplant consistent with the necessary performance, a minimum weight of fuel, of lubricant and of other essential equipment to accomplish the intended voyage with a proper margin may be considered as detrimental but unavoidably so; in a sense an overhead charge against the enterprise. Anything more than the minimum in these non-profitable loads may reasonably be taken as parasitical and should be eliminated. I shall touch upon only one of the elements of these non-productive loads, that is to say the structural frame of the airplane. This structure may be divided into four general groups:

(1) Members subject to tension
(2) Members subject to bending
(3) Members subject to direct compression
(4) Members subject to combined bending and compression

Tension members are in general very simple in design and present a problem essentially of quality of material, as the shape is of small consequence except where exposed to an air-flow. The criteria that may be followed in the selection of the most suitable material are the ratios of yield-point to density and of modulus of elasticity to density.

Bending loads without appreciable direct tension or compression occur in various parts of airplanes. Examples of this group are the wheel axle of land-type airplanes and the tail skids. Direct compression members are well exemplified by the drag struts within a wing or by the interplane struts of a multiplane wing cell. The wing spars or beams of an externally braced airplane provide a good example of the fourth class, as members subject to combined bending and compression.

Relation of Parts

To produce an airplane of maximum strength and of minimum weight at a price for which it can be profitably sold, some arrangements of the parts with relation to each other and to the loads they must carry, also the selection of the best available cross-sectional forms for these parts, are fundamentally necessary. The essential relation of the parts of the structure to each other and to the loads is the one whereby the load is carried but once and then directly to the final supports, and that the supports shall lie approximately in a plane parallel to the load vector, also that in cases where the loading unavoidably causes a bending moment, the support attachments must

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be arranged to produce a moment of contrary sign and, if possible, of the same amount. Over-correction of a force or moment should in general be avoided, as it usually results in an unstable relation of the parts of the framework. Care should also be taken to avoid loads due to secondary bending, and to utilize the advantages of full continuity over any supports. Both may be accomplished in all cases through simple arrangement. As a general principle, complete concentricity of joints should be attained. However, there are exceptions in which a certain amount of eccentricity results in greater strength from a given member.

Costs of construction, if equally good management, tooling and jigs are assured, are kept at the minimum by the selection of sections to which the adjoining parts can be fastened easily and by reducing the number of fastenings to the minimum. Wherever the design permits of power tools instead of hand tools for assembly, the advantages in cost are obvious. Types of section favorable to power-assembly methods are by no means limited to angles, open channels, I-beams and the like but, on the contrary, include the much more structurally efficient enclosed hollow-sections when these are designed especially to afford cheap connection.

FIG. 1—SINGLE-SEATER FIGHTING AIRPLANE IN WHICH ALUMINUM WAS EXTENSIVELY USED

The Lift Wires Are Attached to a Single Point on the Fuselage Instead of Each One Being in the Plane of Its Spar. This Point Was Chosen So That the High-Incidence and Low-Incidence Lift-Drag Force-Vectors Pass through It. With the Commonly Used Wing Profiles the Need of Internal Drag-Bracing Is Almost Completely Eliminated for the Usual Flight-Conditions

Fig. 1 shows a single-seater fighting airplane in which the lift wires are attached to a single point on the fuselage instead of being each of them in the plane of its spar. This point was selected so that the high-incidence and the low-incidence lift-drag force-vectors will pass through it. Such an arrangement, with the wing profiles in common use, almost completely eliminates the need of internal drag-bracing for these conditions of flight, and correspondingly reduces the end loads of the spars.

Fig. 2 shows diagrammatically a single-bay airplane having cambered spars. From inspection it is evident that these upper spars in normal flight, when they are compressed by the lift bracing, and the lower spars in inverted flight, when they in turn are compressed by the landing wires, are curved in such a way that the air loads tend to straighten them while in those conditions of flight where they are simultaneously subjected to compression. If the design is correctly detailed, the spars will be absolutely straight when under their maximum intended loading. Hence the secondary bending-moment that forms the basis of all column formulas and is expressed by the product of the end load by eccentricity is eliminated. Failure occurs only at very high stress and then by a sidewise bending of the spar in the plane of the drag stressing.

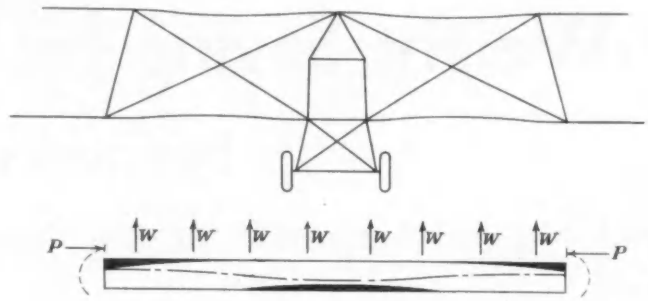


FIG. 2—DIAGRAM SHOWING A SINGLE-BAY AIRPLANE HAVING CAMBERED SPARS

These Spars Are Curved in Such a Way That the Air Load Tends To Straighten Them When They Are Subjected to Compression in Flight, and They Are Absolutely Straight When Their Maximum Intended Loading Is Applied. The Distribution of Material in the Spar Chords Is Illustrated in the Lower Portion

If, instead of curving the entire spar in a sense contrary to the deflection produced by the loading, material is omitted from those parts of the spar-chords where the bending stress and the axial stress are of opposite signs, the gravity axis of the spar becomes cambered in the desired direction. We have then the apparently paradoxical but actually realized result of increasing the strength of a member by decreasing its weight.

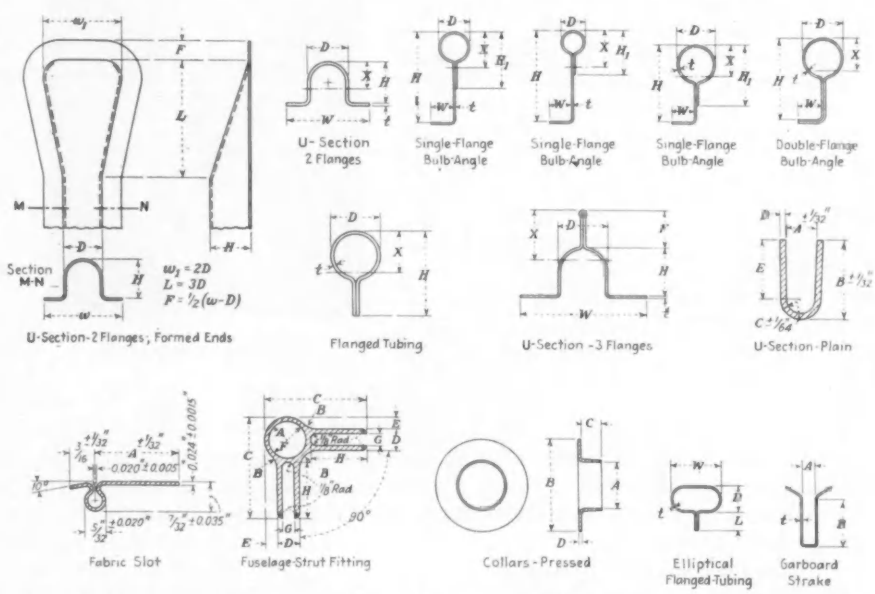
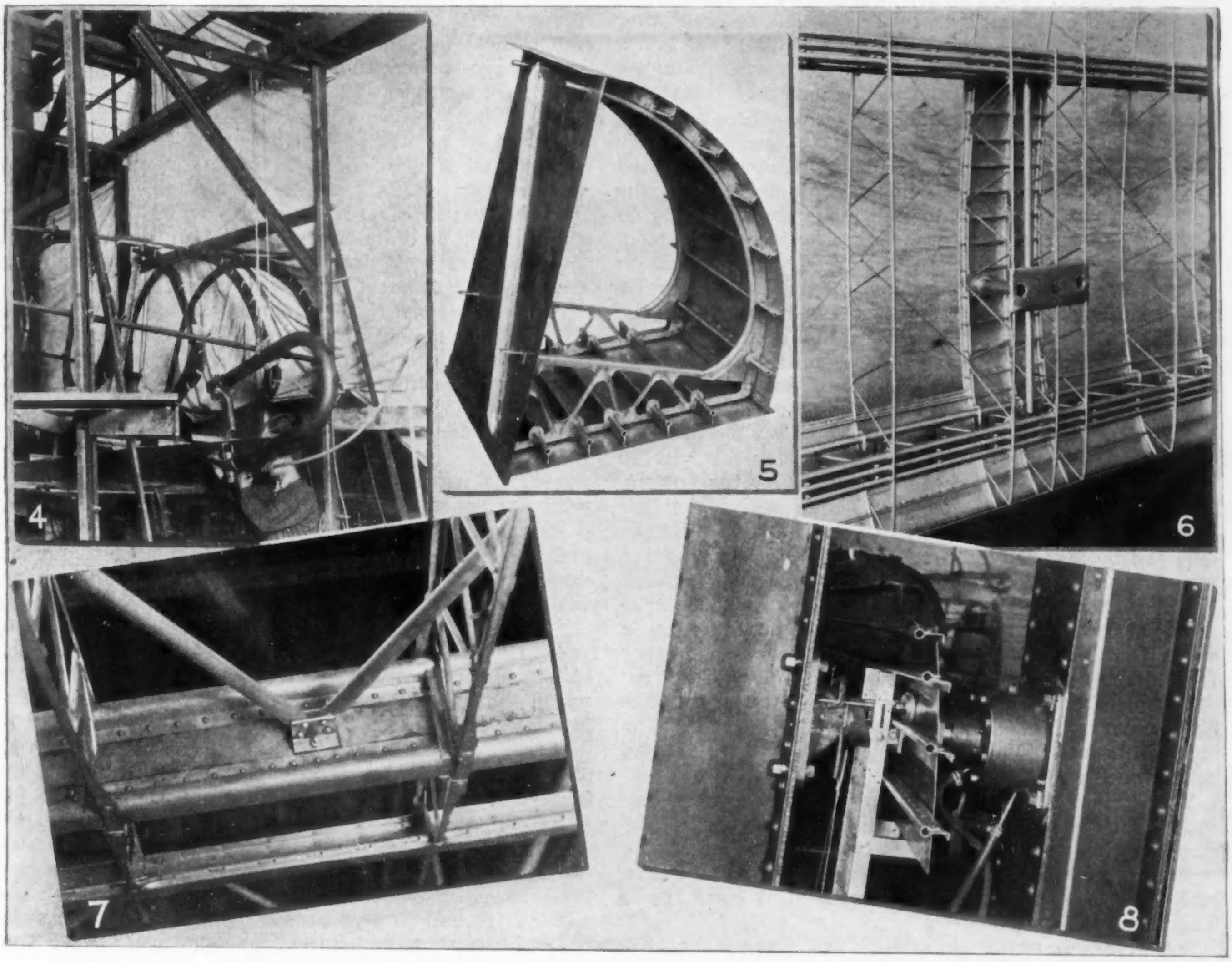


FIG. 3—SECTIONS THAT HAVE BEEN DEVELOPED ESPECIALLY FOR AIRCRAFT USE

These Sections Are Available throughout a Large Range of Sizes and, as Finally Built into a Complete Assembly, Practically All of Them Are of the Closed Hollow-Type and Can Be Considered as Tubes



SOME EXAMPLES OF THE USE OF ALUMINUM FITTINGS IN AIRPLANE CONSTRUCTION

Fig. 4—Semi-Portable Riveting Machine, Weighing 138 Lb. and Having a 38-In. Throat Depth, Which Is Suspended from a Light Crane That Can Be Attached to Any Post of the Assembly Jig

Fig. 5—Half Section of a Float or Pontoon in Which Some of the Standardized Parts Shown in Fig. 3 Are Used

Fig. 6—Detail of the Sidewalk Construction for a Flying-Boat

Fig. 7—Elliptical Flanged-Tubing Used with Flat Sheet as Web Material in the Construction of a Strong, Rugged and Inexpensive Wing-Spar

Fig. 8—Gang Riveting Machine That Performs Three Operations Simultaneously and Effects an Estimated Saving of 70 Per Cent in Plating-Assembly Labor

The lower portion of this diagram illustrates such a distribution of material in the spar-chords.

Sections and Machines Developed for Aircraft

Fig. 3 shows a number of sections that have been developed especially for use in aircraft structures and that are available throughout a large range of sizes. As finally built into a complete assembly, practically all of these sections are of the closed hollow-type. They may be considered as tubes, which form the most efficient columns possible, combined with grips for attachment of other parts. In my experience the use of closed hollow-sections is absolutely necessary if sturdy, stiff, strong and at the same time light-weight structures are to be built. The section in the left upper corner is known as a double-flange U-section and is supplied in long straight lengths or with formed ends, both types being shown. The other sections in the top row, called hollow bulb-angles, are made in three heights of two, three and four times the diameter of the bulb. Flanged tubing is what the name implies, a tube integral along its entire length with a flange for attachment of other parts. A U-section with three flanges is next, then plain U-section followed by fabric slot, fuselage-strut fitting, a pressed collar, elliptical flanged-tubing and garboard strake.

A semi-portable riveting-machine, which weighs 138 lb. and has a throat depth of 38 in., is illustrated in Fig. 4. The anvil can be rotated to any position and is furnished right handed or left handed, which enables reaching within 7/32 in. of any corner. A hand-operated pressure-pad squeezes the sheets together before and during the riveting. As shown, this machine is hung from a light crane that interchangeably attaches to any post of the assembly jig.

A half section of float or pontoon construction of 48-in. beam is shown in Fig. 5 which illustrates the use of some of the standardized parts to which reference

has been made. The pressed bottom-frames are secured to a central bulkhead by a few rivets and to each other in pairs by integral extensions that afford a follow through. The bottom stringers are hollow bulb-angles secured to the frame by encircling pressed clips. The sides and deck frames consist of a sheet-metal angle curved to the correct outline and to the inner edge of which a curved section of flanged tubing is riveted forming in effect a large hollow bulb-angle. By the insertion of a gusset plate this upper frame forms an efficient knee brace at its connection to the bottom frame, its upper periphery is punched at intervals to receive the longitudinal stringers of hollow bulb-angles and secured to these by pressed clips similar to the bottom stringer-clips. The central bulkhead is stiffened and trussed by pairs of two flanged U-sections with formed ends. The chines consist of an angle section over which the plating of the sides and bottom is extended and after the insertion of suitable waterproofing the whole is enclosed by a plain U-section and riveted through. The keel bulkhead extends below the bottom, receiving a length of garboard strake over which the bottom plating extends and after waterproofing is then enclosed by and riveted to a plain U-strip. The frames are fully continuous and the stringers run through without interruption for their entire length. The method of affording continuity when passing through a watertight bulkhead is similar for either stringer or frames and consists of the insertion of a plugged length of seamless tubing extending a short distance into the hollow part of each section where it is secured by through rivets. This tube is provided with pressed collars on each side that retain the sealing material.

This principle of full continuity of all parts at any intersection is by no means confined to boat-frame construction but may be observed throughout all of the structures here shown. It is a most important factor in building strong rugged structures at a very light weight.

When very light weight is required, we use a multitubular spar. This spar, when tested to destruction, shows the characteristic failure of the type, a sidewise bending of the compression chord near midspan. This spar section weighed 3¼ lb. complete with fittings and carried an end load of 4000 lb., plus eight side loads of 186 lb. each, before failure.

The variation in size and in number of the web tubes as well as the omission of the central-chord tube in the upper chord near midspan and the omission of the central-lower-chord tube toward the left support are features of this design and have the effect of shifting or curving the gravity axis as was mentioned earlier. A feature of this construction is the cut-away portions of the interrupted tubes whereby the load is transferred to them gradually by each of four rivets. Were this not done, the rivets or pins would be sheared off progressively in turn. The Y-form of the drag-strut fitting plate, which avoids any change in panel length and the very large secondary stresses resulting from more usual arrangements, is another feature.

A detail of the sidewalk section in the upper center section of the wing for a large flying-boat is shown in Fig. 6. This consists of ribs built up of flanged tubing for cap strips with seamless-tube webs, and a sheet of 17ST 0.024 in. thick which was stiffened at intervals of 4 to 5 in. by one of the smaller sections of hollow bulb-angle. The clips used to secure these stringers to the upper cap-strip of the rib is itself a section of hollow bulb-angle and serves also as an effective reinforcement to the cap strip.

The nose stiffener is of 17ST sheet 0.016 in. thick provided with longitudinal stiffeners of flanged tubing which are secured to the cap strips of the ribs by simple clips. The fabric strip along the edges of the nose stiffener, which was shown in section in Fig. 3, consists of a round bulb of 5/32-in. diameter with a narrow slot between its flanges. The wing-fabric covering is provided with a narrow hem into which an aluminum wire 3/32 in. in diameter is inserted and then the fabric and wire are both dragged into the slot, permanently securing the fabric to the wing panel.

This operation of covering takes two men about 2 min. for each side of a 25-ft. panel. Stitching the fabric to the ribs and stitching at the ends of the panel completes the covering operation. The nose stiffener, being over 2 ft. wide, is not covered by fabric in this case but itself forms the covering and is flush with the fabric.

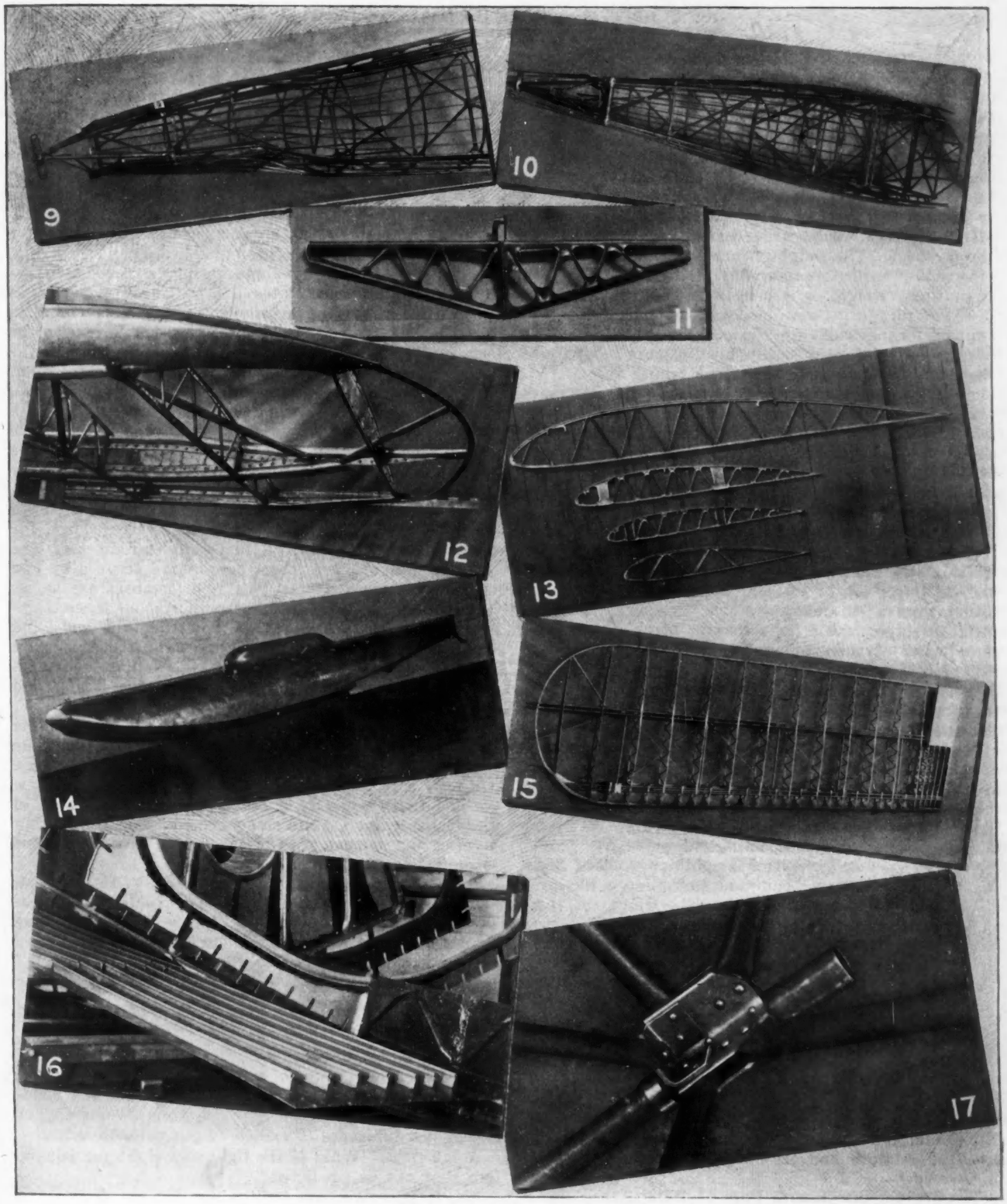
Fig. 7 illustrates the use of elliptical flanged tubing, with flat sheet as web material in the construction of a strong, rugged and cheap wing-spar. This type is not as light in weight as our multitubular type for the same strength but is considerably lighter than usual wooden spars. In this case no wires have been used in the drag bracing, which consists solely of seamless tubes riveted to a simple extruded fitting and, with the spars, forming a Warren truss. The simple way in which this type of spar can be tapered at the wing tips is shown in Fig. 12.

Fig. 8 is a close-up of the gang riveting-machine that performs three operations at once. At one point the plates are cupped into each other, forming a dimple as we call it. In a dimple just formed a hole is punched and in this punched hole a rivet is headed flush with the outside of the plate. Each time the jaws close these three operations take place, resulting in a completed rivet and in preparation for the next two rivets. We estimate that this method saves at least 70 per cent of the plating-assembly labor.

Fig. 9 shows the rear half of a three-seater 300-hp. Autogiro fuselage after it had been run into by a motor-truck. The bent sections of longeron were cut and slipped through the adjoining fittings, and new straight tubing with slip liners was slid into place and joined by through rivets. The web members that were too badly bent to be straightened were removed by cutting off their rivets and new ones slipped into place and secured by rivets 1/32 in. larger. The fairings which are made of flanged tubing, both for the formers and stringers, were either straightened or new lengths slipped on and secured.

Two days later this fuselage appeared as shown in Fig. 10 and has been in regular use since. The weight of this fuselage complete with all external fittings, seat and tank supports, floor supports and fairing was 108 lb.

Fig. 11 illustrates a pair of blanked and pressed bottom frames for flying boats or floats up to 48-in. beam. The tapering and filleting of parts is similar to that to be described later for pressed wing-ribs. These frames weigh 0.55 lb. for a thickness of 0.05 in. and the dies allow for variation in thickness from 0.072 to 0.040 in., permitting stronger frames to be used in the more heavily loaded parts of the float. The dies also allow for the narrower beam usual near the bow and the stern.



Other Typical Uses of Aluminum in Aircraft Construction

Fig. 9—Rear Half of a Fuselage After Being Damaged by a Motor-Truck

Fig. 10—Fuselage Shown in Fig. 9 Two Days Later After Repairs Were Made

Fig. 11—A Pair of Blanked and Pressed Frames for Flying Boats

Fig. 12—An Example of How Easily the Type of Spar Illustrated in Fig. 7 Can Be Tapered at the Wing Tips

Fig. 13—Several Sizes of Wing Rib Which Illustrate the Various Types of Construction Possible

Fig. 14—A Completed Amphibian Float Having a Displacement of Approximately 10,000 Lb.

Fig. 15—Multitubular Spars with Ribs Pressed from Sheet Material

Fig. 16—Hollow Bulb-Angle Stringers Attached to the Outer Plates of a Flying-Boat Hull and a Transverse Frame That Is Slotted To Receive the Stringers

Fig. 17—An Extruded Joint-Fitting That Is Slipped over the Longeron and Secured by Through Rivets. The Web Members Are Tubes with Flattened Ends That Are Slipped between the Lugs of the Fitting

Several sizes of wing rib are illustrated in Fig. 13. The top and bottom ones have cap strips of flanged tubing. In the bottom rib the web members are also flanged-tubing while, in the top rib, the web members are of seamless tubing. In either case the only fastening necessary is a single rivet at each intersection of web and cap strip and the web member is flattened and inserted between the flanges of the cap strip. Assembly is remarkably fast when done in a universal type of steel jig which centers the web and chord flanges on the rivet hole. The weight-strength ratio of this type of rib usually varies between 1000 and 1300 and in spite of its light weight it is remarkably sturdy. One evidence of this is its continued and undamaged use as a support for sidewalks for Navy airplanes. Such ribs can readily be reinforced locally by the mere insertion of the next standard size of flanged tubing into the cap strip and when accidentally broken they are readily repaired in a similar way without removal from the wing panel. The two center-ribs, respectively 60 and 48-in. chord, are each blanked and pressed to form in polished steel dies from a single sheet of 17S aluminum alloy. Larger pressed-type ribs are made in three sections, nose, center and tail.

The enlarged fillet ends of the web members where they are supported on the chords should be noted, also the variation in size of the several webs and of the various parts of the chords, enough material for the load members but not too much anywhere. The web members taper along their length, being 8 or 10 per cent larger at their mid-points than near their ends. This slight cutting away of material near the ends curves the gravity axis of the struts with the result that the rounded center is forced to carry a larger stress than the average and the free edges somewhat relieved of load. In the usual proportions this enables at least 40 per cent more load to be carried by a given sectional area. These pressed ribs usually have a weight-strength ratio between 1800 and 3000. As will appear from other illustrations, they are sturdy and capable of taking much abuse, as when supporting sidewalks.

Fig. 14 shows a completed amphibian float of 27-ft. 6-in. length and 48-in. beam and 36-in. depth, having a displacement of about 10,000 lb. The weight of these amphibians, including all wheel gear, operating gear in the cockpit and similar parts complete, is about the same as that of similar floats as currently built but without any of the amphibian features.

An example of spars of the multitubular type with ribs pressed from sheet is given in Fig. 15. The sidewalk is a sheet 0.024 in. thick which is riveted directly to the ribs. This wing panel for a modern single-seat fighting airplane weighs 33.42 lb. in the condition shown. When fabric covered, doped and finished the weight is 42.75 lb. The area is 50.7 sq. ft.

An interesting development used in our plant for several years and not before published, is shown in Fig. 16. Here hollow bulb-angle stringers have been assembled to the outer plates of a boat hull. The unit is shown ready for the attachment of the stringer clips and also the transverse frames as slotted to receive the stringers. Final assembly consists in punching the stringer clips and frames and riveting these together, both operations being performed by pneumatic tools. The assembling of plating and stringers is done in a gang riveting machine which has capacity for the sheets up to 72 in. wide. Guides for locating the stringers are attached to the vertical members below the riveting heads.

One of the uses for the extruded joint-fitting is shown in Fig. 17. This is now available in four sizes for longerons ranging from $\frac{3}{4}$ to $1\frac{1}{8}$ in. in diameter. The fitting is slipped over the longeron and secured by two or more through-rivets. The web members are tubes, into the ends of which a tubular liner about three diameters long has been pressed, and the tube ends and liners are flattened in a special forming tool that sizes them to a press fit on a flat lug. These flattened tube-ends are slipped between the lugs of the fitting and secured by two rivets.

Fuselage diagonal stays are secured to a bent plate and this plate is fastened to the fitting by the same rivets that secure the web tubes between the fitting lugs. On test, both the longeron and the web members show an end fixity equal to a coefficient of 2.15 to 2.90 in the Euler formula when so connected. The ring fitting joining one section of longeron to the next section of smaller diameter should be noted.

This showing of various examples of types of light, strong and economical airplane construction is necessarily fragmentary. Time is not available for more than a glance at a few of the contributing factors.

THE DISCUSSION

CHAIRMAN A. W. MOONEY[2]:—I am sure we feel greatly indebted to Mr. Hall for disclosing these types of construction that he has worked out. This subject of weight saving by structural efficiency is something that should merit a very thorough discussion inasmuch as all of us have had occasion to fight weight at all times.

Weight per Square Foot of Wing Area

A MEMBER:—What is the lightest weight per square foot that Mr. Hall predicted for fabric construction on the tapered wing and straight wing?

CHARLES WARD HALL:—The difference in weight between straight and tapered construction is not necessarily great. The detailing of the latter construction covers so many different parts and so few of each that it is rather laborious to make them all economically. That somewhat offsets the fact that we have less bending loads to carry on the tapered wing. I should not expect the difference to exceed 10 per cent.

A MEMBER:—What is the lightest weight per square foot that can be predicted?

MR. HALL:—We have built wings for 10,000-lb. ships weighing as little as 0.92 lb. per sq. ft. and have never exceeded 1.13 lb. per sq. ft. for complete wings, covered and including the external bracing.

I agree with Mr. Gassner that the more we increase the aspect ratio, the greater is the tendency to run the weight up. On the other hand, I do not agree with him that the larger ship necessarily has the heavier weight per unit wing-area.

WESLEY L. SMITH[3]:—Has Mr. Hall applied that type

[2] Jun. S.A.E.—President, Mooney Aircraft Corp., Wichita, Kan.

[3] A.S.A.E.—Chief engineer, National Air Transport, Inc., Chicago.

of construction to full-cantilever or semi-cantilever wings? Are there any practical forms of these as yet?

MR. HALL:—The full-cantilever wing is nothing but the tip of a broad wing. We cannot see anything distinguishing about it. If you can afford to have an airfoil section 20 per cent thick instead of the usual 11 per cent at the base of the cantilever, the spar depth available allows an aspect ratio of 5 or 6 as compared with the usual broad overhang of $1\frac{1}{4}$ to $1\frac{1}{2}$ chords.

CHAIRMAN MOONEY:—What is considered a good average weight per square foot of full-cantilever wing of the conventional type of construction or of a fabric-covered structure of the full-cantilever type? Does an engineer consider $1\frac{1}{2}$ lb. per sq. ft. as satisfactory or not?

A. W. MOONEY

A MEMBER:—Wright Field has been conducting tests of tapered wings with a 55-ft. span and a maximum chord of 11 ft. and comparing all the various kinds of structure that are submitted for tests. Some metal-covered types weigh 1.75 lb. per sq. ft. With fabric covers and duralumin construction and by tapering the sections as Mr. Hall has indicated, obtaining the least weight in all members seems possible; by a complete analysis, we might obtain 1.1 lb. per sq. ft., which is the closest analysis I have been able to arrive at by tapering all sections. Captain Green is conducting the test down there and will submit a report, I suppose for publication, within a year or so.

CHAIRMAN MOONEY:—When the time comes that those figures are actually on the airplane, the time will also have arrived when we shall have made very marked progress toward carrying a bigger load. I am under the impression that the average job weighs considerably more than that right now per square foot.

GARLAND POWELL PEED, JR.[4]:—On a job in production a two-piece wing weighs 535 lb.

CHAIRMAN MOONEY:—That is a jointed wing.

MR. PEED:—It is a three-piece wing that weighs about $2\frac{1}{4}$ lb. per sq. ft. including the tanks and everything else that is in it. The fuselage weighs only 95 lb. uncovered. What does Mr. Hall expect from the aluminum alloy, beryllium?

WESLEY L. SMITH

MR. HALL:—I would not like to make a prediction as beryllium cannot come into use until the price is reduced and that probably cannot occur until it is used extensively. From a laboratory point of view the metal looks interesting.

A MEMBER:—Is the Aluminum Co. of America prepared to deliver the cold-worked SRT aluminum alloy in large quantities at present? Would using 17SRT at lower cost and lower weight be more economical than using 17ST?

MR. HALL:—I do not feel that I am in position to speak for the Aluminum Company, so I can only repeat gossip. That type of material is now being delivered for the Goodyear Zeppelin. One serious objection to the RT material for use around salt water is that it is much more susceptible to corrosion than the normal material. At first when coated with pure aluminum it was not as readily protected as is the usual run of 17S. That problem I think is still under investigation.

JOHN D. AKERMAN[5]: — How would duralumin covered with bitumastic paint for protection against sea water compare in weight with stainless-steel construction? In salt-water use a pontoon covered with at least two coats of bitumastic paint has a considerable quantity of this heavy paint inside and outside. Could not we eliminate the paint and use stainless steel instead of duralumin? What is Mr. Hall's opinion about that kind of construction?

MR. HALL:—I have had no experience with stainless steel in that exposure. To start with, it would have to be about one-third as thick to weigh the same, assuming the same type of reenforcements, or we would have to space our reenforcements three times as close together. It is a type of problem that I would hesitate to say very much about without having tried it. Corrosion is not necessarily accompanied by the use of two coats of bitumastic paint as a cure. We have had success with nothing but a very thin coat of hard grease applied like Simoniz. An example of that is a little flying-boat that was built in 1922 or 1923, lay in Long Island Sound for a whole season, was pulled out on a low uncovered float for three succeeding seasons and was flown last summer. It is still free from any signs of corrosion at all.

JOHN D. AKERMAN

MR. PEED: — We used Metalclad, which is a thin layer of wood covered with duralumin or aluminum, on the bottom of flying boats and the duralumin would peel from the wood. For a series of tests we used very thin Bakelite. It would not break or crack in any way and it seemed to carry its load very well. We covered the bottom of a small test section, about 2 ft. square, with very thin Bakelite. No corrosion resulted, no paint was needed and the bottom was very slippery. The Bakelite slid through the water very easily and was applied directly to wood and stringers by countersunk screws, the use of which also reduced friction.

CHAIRMAN MOONEY:—That material has been used for leading-edge cover under cloth and in several other places.

[4] Aeronautical engineer and consultant, Hotel Plaza, New York City.

[5] Professor of aeronautics and acting head of the department of aeronautical engineering, University of Minnesota, Minneapolis.

Scientific Inspection Reduces Motorcoach Operating Costs

By H. B. Hewitt[1]

Transportation Meeting Paper

THIS PAPER is both a plea to manufacturers of commercial vehicles and their units to cooperate with operators in scientific study of maintenance problems and an exposition of inspection methods that have reduced the operating costs of a large system of city-type motorcoaches.

The author comments upon the large expenditures of the manufacturers of automotive equipment upon research laboratories for the improvement of the quality and reduction of the cost of vehicles. He concludes with the suggestion that the diversion of some part of these facilities to the solution of maintenance problems will reduce the cost of operating commercial vehicles sufficiently in some cases to enable the operators to purchase additional vehicles. He urges the lifting of the ban against furnishing factory blueprints and working drawings to maintenance men and the establishment of standard practices for repair shops.

Inspection for the detection of errors should be based on a knowledge of facts obtained by scientific research, and data so obtained should be preserved under one form so that a standard practice can be established. Maintenance inspectors should be highly specialized, properly instructed in standard-practice procedure, and know labor and material costs.

The author asserts that the correct method for ascertaining the time to make repairs, adjustments or replacements to commercial vehicles should be based on condition of the vehicles rather than upon time or mileage, and that men developed as diagnosticians rather than inspectors should determine the extent of repairs to be made and the time to make them. He then describes the maintenance methods followed by the operating organization he represents and gives charts and tables showing substantial increases between inspection periods and large reductions in mechanical failures per mile operated.

WITHIN the last few months I have visited the factories and research laboratories of some of the largest manufacturers of automotive products. In these laboratories scientific tests and investigation are applied to an extent that would be amazing to not only the automobile owner but to experienced automotive men and old-timers who have seen our automotive equipment develop from a temperamental group of units that had the balky characteristics of a mule to the beautifully coordinated mechanical devices which are the thoroughbreds of today. More than 1200 engineers and scientists in one organization and more than 600 highly specialized men in another are searching for facts and information upon which to improve the quality and reduce the cost of our automotive vehicles.

Millions of dollars are invested in plant and equipment for research work, but, because of the great number of vehicles produced, the cost of the research work averages less than 50 cents per vehicle produced. In the production plants, after definite standards are established by research and engineering, uniformity of quality and performance of automotive vehicles is accomplished only through the effectiveness of inspectors.

Inspection is a critical examination to detect errors, but, to accomplish this, it is necessary to have a definite knowledge of particular facts obtained and shown to be correct by scientific research. When definite knowledge is established, a record should be made for the purpose of accumulating and preserving all data under one form so that a standard practice is established.

The value of standard practice applied to the maintenance of motor-vehicles is that it brings about a coordination of information and uniformity of instruction for the maintenance of one type of equipment in a single manner. Standard clearances, tolerances and adjustments are specified and used as a basis to detect errors when inspections are made of motor-vehicles or their units.

Inspectors Must Be Familiar with Costs

Labor employed to make inspections is necessarily highly specialized, and men selected for this purpose should have specific characteristics that fit them for this class of work. They should have keen observation, mechanical sense, accuracy, thoroughness and practical judgment. Such men, properly instructed in standard-practice procedure, are valuable in the scientific detection of faults in equipment used for motor-vehicles.

It is important that maintenance inspectors be familiar with costs of labor and material required to make various repairs, as the expenditure of money should be a major consideration in deciding the extent of the repairs and the time when they are to be made. Competition in commercial-vehicle operation makes imperative the closest scrutiny of all maintenance procedure so as to effect economies that will help reduce operating costs.

I feel that the more economical basis for the main-

[1] Engineering assistant to vice-president in charge of operation, Mitten Management, Inc., Philadelphia.

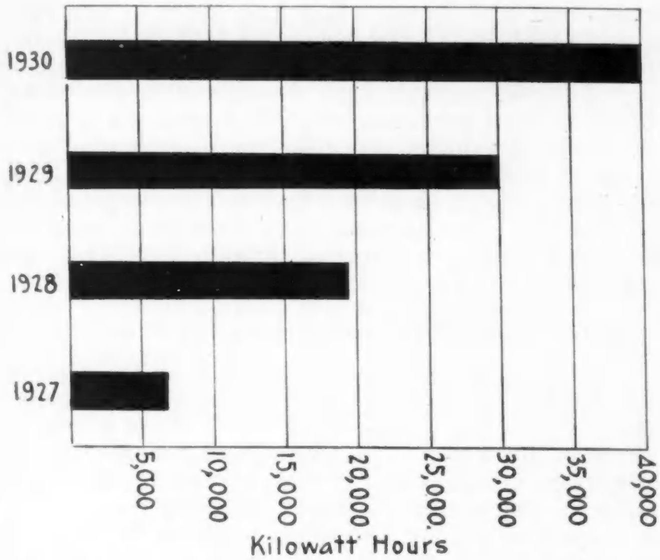


FIG. 1—INCREASE IN KILOWATT-HOURS BETWEEN CLASS-C INSPECTIONS IN THREE YEARS

Inspection Is Based on Kilowatt-Hours Instead of Time in Service or Miles Operated by the Gasoline-Electric Motorcoaches of the Philadelphia Rural Transit Co. The Kilowatt-Hour Consumption per Mile Is 0.96 Kw. for Parlor Coaches, 1.01 Kw for Single-Deck City-Type Coaches, and 1.28 Kw. for Double-Deck City-Type Coaches

tenance of motor-vehicles can be determined only after making a study of the particular vehicles selected and the operating conditions under which they are to be used.

The expected life of a vehicle or unit is one of the determining factors in setting up a maintenance program. The amount of money appropriated for maintenance plus depreciation is usually adjusted according to operating conditions. The relation between maintenance cost and depreciation can vary according to the results desired. With depreciation spread over a period of 10 years or the equivalent in miles, the maintenance cost would be relatively high and the depreciation low. With depreciation spread over a period of 5 years, the depreciation would be relatively high and the maintenance low; but in each case the total figures should be approximately the same under similar operating conditions.

Condition Should Be Basis of Repairing

It is impractical to maintain in operation standards of clearances and tolerances set up by vehicle manufacturers; therefore, maintenance standards are established which will produce a commercial efficiency sufficient to give satisfactory and economical operation.

With the development of measuring devices that provide accurate means of obtaining facts pertaining to the condition of the various parts of the motor-vehicle, it would seem that the correct method for determining the time to make repairs, adjustments or replacements should be based on existing conditions and facts rather than upon a measurement of time or mileage. Under this method, men developed to be diagnosticians rather than inspectors would determine the amount of repairs and the time the repairs are to be made.

The replacement of parts, overhauling of units or making repairs of any character upon the basis of time or mileage does not seem economically sound. The application of such units of measurement to the life of tires would obviously be wasteful; therefore, the general practice is to continue tires in service as long as there is no indication of weakness that would cause a failure while in service. This principle can be applied to other motor-vehicle units which are not as accessible for inspection, by the development of test procedure to determine actual conditions upon which decisions can be based for making repairs or replacements.

Increase in Time Between Inspections

Manufacturers and maintenance engineers have made great progress in developing equipment and service methods that make the operation of vehicles for a greater number of miles between inspection periods both safe and economical. Fig. 1 is a chart of increases between inspections for one of Mitten Management's operations in which both single-deck and double-deck city-type motorcoaches are used. The kilowatt-hour,

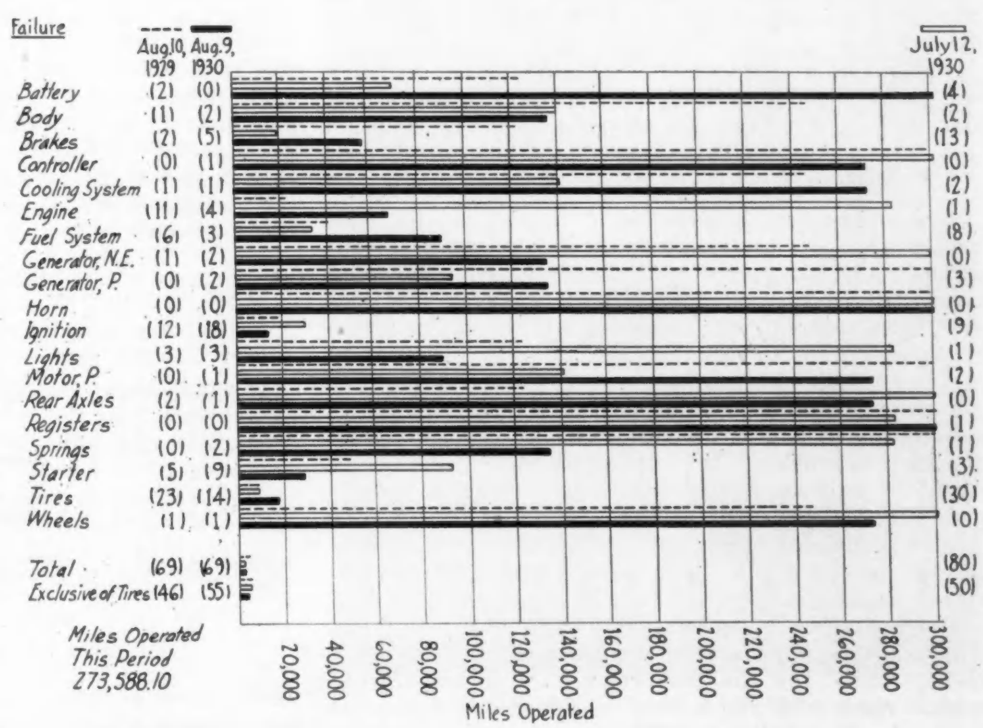


FIG. 2—RECORD OF EQUIPMENT FAILURES AND MILES OPERATED PER FAILURE BY THE CUMBERLAND GARAGE DURING THREE FOUR-WEEK PERIODS

The Chart Compares the Period Ended Aug. 9, 1930, Represented by the Solid Lines, with the Corresponding Period in 1929, Shown by the Dotted Lines, and with the Preceding Four-Weeks Period in 1930, Shown by the Open Lines

TABLE 1—SERVICE CALLS ON ACCOUNT OF MECHANICAL FAILURES

	1929	1928	1927	1926
Pull-Ins; Bus Changes				
Mechanical Failures	1294	1606	1559	3151
Per Cent of Buses Operated	1.49	1.93	2.18	....
Delays; No Bus Changes				
Mechanical Failures	180	920	731	2778
Per Cent of Buses Operated	0.20	1.11	1.02	....
Total Mechanical Failures	1474	2526	2290	5929
Per Cent of Buses Operated	1.69	3.04	3.20	....
Service Calls; No Bus Changes nor Delays				
Mechanical Failures	448	1515	....	....
Per Cent of Buses Operated	0.51	1.82	....	....

rather than time or mileage, is used as a unit of measurement, as all of the vehicles in this operation are gas-electric and the kilowatt-hour meter records the unit of work, taking into consideration speeds, loads and grades. Vehicles in this operation are inspected upon the following schedule:

		Miles		
Inspection	Kilowatt-Hours	Parlor Coach	Single-Deck	Double-Deck
B	3,500	3,650	3,470	2,030
C	40,000	41,600	39,500	31,200

Fig. 2 shows the mechanical-failure record for three four-week periods of a group of single and double-deck gas-electric coaches used in a city operation. A comparison of the records of three garages in the same operation is made in Fig. 3. Similar charts are posted in the garages and create a spirit of competition among the foremen, inspectors and garage crews and also show the progress and improvement accomplished by the garage management. These charts are also guides to the effectiveness of the inspection system and are a record of all mechanical failures, with and without delays.

Table 1 is a comparison of the number of failures, with and without delays, for a three-year period of the city operation above mentioned.

Localizing Work Concentrates Responsibility

Experience in the operation of automotive vehicles has resulted in the transfer of a considerable amount of the inspection and repair work from a central automotive repair-shop to the operating garages. In general, there seems to be a movement among the operators of large groups of vehicles toward decentralizing inspection and maintenance work. One of the important accomplishments in localizing this work is the elimination of divided responsibility. By placing with the garage manager the control of money spent for mantenance, many expensive practices and extravagances in the use of material are eliminated.

In Philadelphia, each garage manager of cabs and coaches of the Philadelphia Rural Transit Co. is assigned a specific number of vehicles for which he is held fully responsible. If special events require the temporary transfer of equipment from one garage to another, the responsibility for the performance of a transferred vehicle rests with the garage to which the vehicle is assigned. This policy has led to some very interesting developments. Every foreman, in his efforts to reduce costs, soon learns to work very close to the limits beyond which unsatisfactory operation would occur. As an example, if a bus that is normally in service carrying heavy loads on a comparatively slow schedule were transferred to a garage where high speed is required, it would probably fail in service the first day of operation. Therefore, when transferring buses, it is necessary for the foreman who is responsible for those operating on a particular route to thoroughly inspect the borrowed vehicles and make the necessary adjustments to assure satisfactory performance. This does not, by any means, mean that the buses are in generally poor condition, but is used as an illustration to show the possibilities of economies through intelligent inspection.

Mitten Management Experiences and Practices

Some of the experiences and practices in the Mitten Management's automotive-vehicle operations are as follows:

Testing Procedure.—The form used for testing in the garages is reproduced in Fig. 4, showing the front and back. The testing panel used in each of the garages for inspection of bus equipment is shown in Fig. 5. This panel has a voltmeter, an ammeter and an indicating wattmeter to measure the output of the engine. A water rheostat is used to load the engine. The electric tachometer indicates the engine speed, and a fuel meter is used to measure fuel economy at various loads and speeds corresponding to regular operation. The manometer on the right of the panel is used to measure back pressure in the exhaust system of the engine, which is an important item of inspection, as the indications of this instrument provide information pertaining to the amount of carbon accumulated in the exhaust system or other abnormal conditions which would increase the exhaust back-pressure and result in loss of power.

For a six-cylinder motorcoach engine running at 2000 r.p.m., with a back pressure of 60 oz., the output is 95 hp. With this back pressure reduced to 10 oz., the horsepower output is 105, or an increase of more than 10 per cent at 1400 r.p.m. With a 60-oz. back-pressure, the output is 71.8 hp.; and with a 10-oz. back-pressure it is 77 hp., an increase in horsepower of more than 8 per cent. In an engine of this size and type the average power loss is approximately 2 hp. per lb. of back pressure.

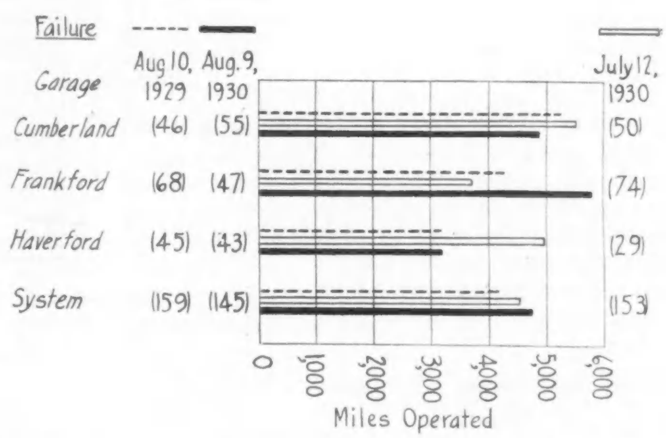


FIG. 3—COMPARATIVE FAILURE-RECORD OF GARAGES BY FOUR-WEEK PERIODS

Charts Like This Are Posted in the Several Garages of the Company and Create a Spirit of Competition among the Foremen, Inspectors and Garage Crews. They also Show the Progress and Improvement Made by the Garage Management, Serve as Guides to the Effectiveness of the Inspection System and Are a Record of All Mechanical Failures, with and without Road Delays

STANDARD ELECTRICAL AND ENGINE TEST

R. S. AND S. DEPARTMENT

Bus No. Date

	RUN 1 * AS REC'D	RUN 2		RUN 3		RUN 4	
1 *R. P. M.							
2 *P. G. Volts							
3 *P. G. Amps							
4 *K. W. Output							
5 Ex. Back Pres.—Oz.							
6 Co.—H_2 %							
7 Gas.—Min.—Sec.							
8 Gas.—Sec. for 1 qt.							
9 Gas.—Qts. per K. W. H.							
10 Ignition Setting							
11 Carburetor Setting							
12 Compression							
13 *Relay Voltage—Open							
14 *K. W. Meter Test—%							
(a) Meter Constant							
(b) Volts							
(c) Amps							
(d) Revolutions							
(e) Seconds							

15 "Meg" Insulation Test ____ Ohms

16 K. W. Meter Reading—End of Test ____

17 K. W. Meter Reading—Start of Test ____

18 K. W. Meter Reading—Last S. R. ____

19 K. W. Hrs. Since Last S. R. ____

20 Record all Changes and Adjustments—Also any Trouble Located:

21 Oil Pressure:

(a) Idling ____

(b) Full Throttle ____

Type S. R. ____

TESTER

INSTRUCTIONS FOR MAKING ELECTRICAL AND ENGINE TESTS

1. Connect power generator test terminals on side of bus to water barrel cables.
2. Connect cold water supply to radiator.
3. Connect radiator overflow to drain.
4. Connect tachometer drive to front end of crankshaft.
5. Drill and tap exhaust manifold and make connections to CO meter.
6. Connect carburetor to gasoline test tank.
7. Connect carburetor control cable.
8. Record K. W. meter reading.—No. 17.
9. Start engine and record Items 1, 2, 3 and 4 under Run 1 at 1500 R. P. M., wide open throttle.
10. Set ignition for maximum power at 1500 R. P. M.
11. With wide open throttle make run at 1500 R. P. M. and record Nos. 1, 2, 3, 4, 5, 6 and 7 under Run 2.
12. With wide open throttle make run at 1700 R. P. M. and record Nos. 1, 2, 3 and 4 under Run 2.
13. If Items 4, 5, 6 and 7 are within R. S. and S. standards, stop engine and seal ignition.
14. If Items 4, 5, 6 and 7 are not within R. S. and S. standards, make necessary adjustments, recording all changes under No. 20.
15. After making adjustments, repeat Run 2 under Run 3.
16. Engine must either be brought up to standard or reason noted under No. 20.
17. At end of power test check K. W. meter as follows: Record 14a, 14b and 14c as stamped on meter plate.
18. Start engine and hold these values until meter dial makes ten revolutions. Record time in seconds and figure meter error by following formula No. 14.

$$\% = \frac{3600 \times K. \times \text{Revolutions}}{\text{Sec.} \times \text{Volts} \times \text{Amperes}} \times 100$$

19. If meter is over 1% fast or slow make necessary adjustment.
20. Attach voltmeter to cut-out relay terminals and bring engine up to speed slowly, recording voltage at which contacts open. This should be 60–70 volts. Make any necessary spring adjustment.
21. Make "Meg" insulation test while units are hot.
    K Buses: Resistance tube to ground.
    H and J Buses: Series terminal on relay to ground.
    Exciter Circuit: Resistance tube to ground.
    Minimum limit 250,000 ohms.
    If complete circuit is less than 250,000 ohms, test units separately.
    If all units individually are more than 250,000 ohms, equipment O. K.
22. At completion of test, record Nos. 16, 18 and 19.
23. For No. 9 use the following formula:

$$\text{Qts. per K. W. Hour} = \frac{3{,}600}{\text{Seconds per Quart}} \times \frac{1}{\text{K. W. Output}}$$

CAUTION

At no time during test should engine be allowed to run continuously for more than four (4) minutes at wide open throttle.

Tester to sign in lower right corner and return to garage foreman.

FIG. 4—FRONT AND BACK OF FORM USED IN THE GARAGES FOR RECORDING TESTS OF THE ENGINES AND ELECTRICAL CONDITION OF THE CITY COACHES

Megohmmeters.—These are used in all garages for testing insulation. Many times a fault in electrical circuits can be detected with them before the electrical equipment is seriously damaged. The procedure is to measure the resistance of the entire vehicle and, if this is less than 250,000 megohms, the resistance of the various electrical units is measured separately until the source of the trouble is located.

In many cases, carbon dust from the brushes forms a bridge to ground, which trouble is easily eliminated, but which, if permitted to continue, would make expensive repairs necessary.

Engine Compression.—In connection with the scheduled inspection, the compression of each cylinder is measured with a compressometer and if the compression is within the standard limits the engine is continued in service. The permissible variations in these measurements vary accordng to the character of the operation in which the bus is used. City-service buses have lower compression and greater tolerances than high-speed intercity coaches.

Leave Well Enough Alone

Diagnosis.—The complete test report is reviewed by an inspector or foreman in charge of the garage, and repairs or adjustments are ordered according to existing conditions and facts.

One of the rules now in effect is that, so long as the vehicle is in a satisfactory operating condition, as shown by facts obtained from inspection and tests, no repairs

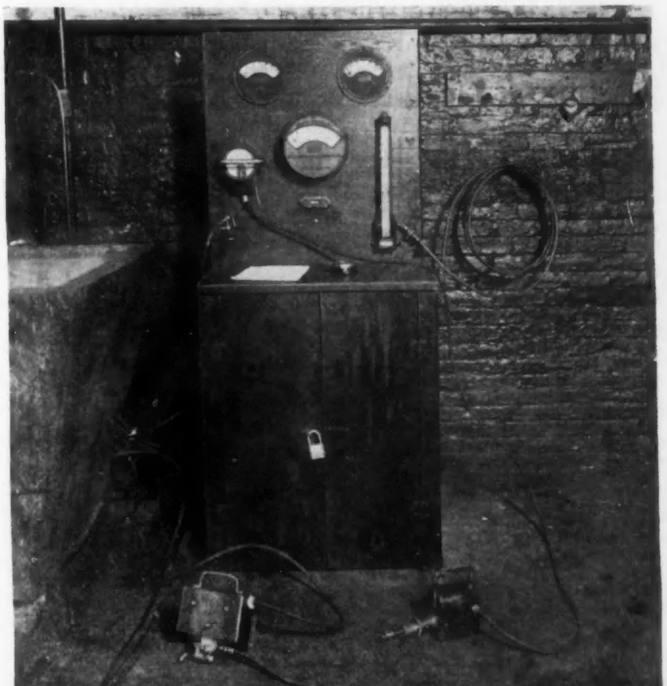


FIG. 5—TESTING PANEL USED IN EACH GARAGE FOR INSPECTION

It Has a Voltmeter, an Ammeter and an Indicating Wattmeter for Measuring Power Output of the Engine at the Generator; a Water Rheostat for Loading the Engine; an Electric Tachometer for Indicating Engine Speed; a Fuel Meter for Determining Consumption at Various Loads and Speeds; and a Manometer for Measuring Back Pressure in the Exhaust System

are made. Our experience has been that when a program of making repairs or replacements upon a definite schedule of time or distance was in effect, the opening of an engine or the replacement of a unit often resulted in a failure or unsatisfactory operation, because the balance of the vehicle as a unit was disturbed by an injection of the human element.

Setting Ignition.—Ignition timing and ignition efficiency probably are more subject to the guess method of adjustment than any other item on the vehicle, as scientific accuracy is very difficult to obtain without special education of the workman. The general practice of most garages and repair shops is to guess at the spacing of the spark-plug electrodes and at the setting of the ignition contact points.

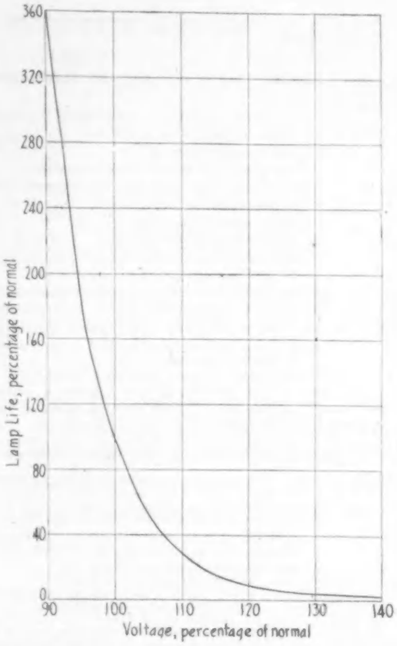


FIG. 6—CHARACTERISTIC CURVE OF ELECTRIC-LAMP LIFE AT VOLTAGES VARYING FROM NORMAL

The Curve Is Plotted from Data Supplied by the General Electric Co. The Normal Life and Normal Voltage Are Indicated as 100. A 10-Per Cent Decrease in Voltage Increases the Lamp Life 260 Per Cent, Whereas an Increase of 10 Per Cent over the Normal Voltage Decreases the Normal Life by 70 Per Cent

With a given setting, as marked on the flywheel, considerable variation in the timing is made by a variation in either spark-plug setting or breaker contact-point setting. Other conditions being equal, a variation of as much as 10 per cent in fuel economy will exist if these particular adjustments are not accurately made. The factory settings are not always the most efficient for a particular operation, as most factory adjustments are a compromise made necessary by the distribution of the vehicles over territory having a wide variation in temperatures and altitudes. Therefore settings which are best for a particular service should be established.

The importance of accuracy in setting the timing can be established by the effect of variation in gasoline economy in an operation totaling 17,000,000 miles per year. An increase of an average of 1/10 mile per gallon effects a saving of more than $21,000 per year.

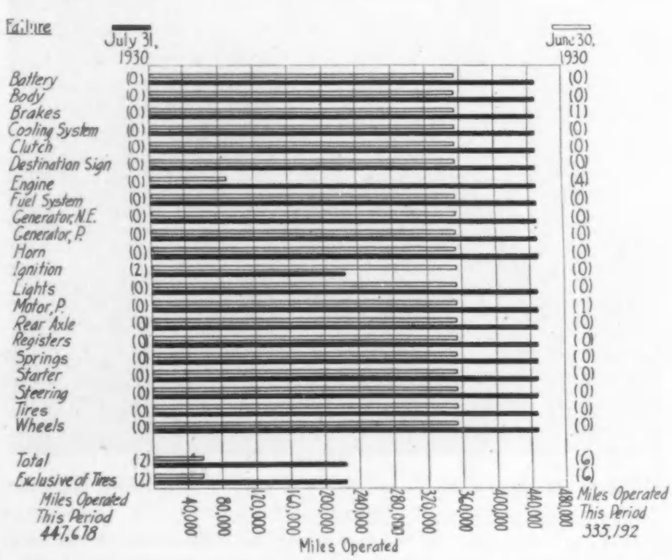


FIG. 7—COMPARATIVE CHART OF MILES OPERATED PER MECHANICAL FAILURE IN LONG-DISTANCE HIGH-SPEED SERVICE DURING TWO FOUR-WEEK PERIODS IN 1930

Higher-Candlepower Lamps Effected Saving

Lamp Life.—One of the unusual cases in which scientific investigation resulted in figures that were surprising to the operator was experienced in one of the Mitten Management bus operations. The garage foreman reported frequent renewals of 6-cp. lamps used in the destination signs. A test showed that the voltage at the lamp sockets with a 6-cp. lamp was 11.3 volts and with a 15-cp. lamp was 10.0 volts; therefore the larger lamp burned at approximately 4.4 per cent lower voltage than the smaller lamp, owing to the resistance of the circuit. This lower voltage represents 80 per cent longer life and, as the cost of the lamps is exactly the same, a very definite saving was made in cost of lamp renewals and a considerable improvement in the appearance of the signs on the buses was accomplished as well. A characteristic curve of Mazda lamp life is given in Fig. 6.

This garage foreman found a practical solution of the trouble and also obtained much-needed additional illumination for the destination signs, but, as a general remedy for such troubles, the solution is not good engineering. However, the moral of this story is that careful, competent inspection and adjustment of voltage-regulating devices will substantially reduce the cost of lamp renewal.

Batteries.—For commercial service, batteries of greater capacities than those the vehicle manufacturers usually include as standard equipment have proved economical for trucks, taxicabs and buses. One competent battery repairman does the repair work for more than 1700 vehicles. The bus batteries average 48 months in active service, a length of life that is accomplished by inspection under well-supervised standard practice.

Door Inspection.—One of the principal factors in reducing service failures in Mitten Management properties is the development of a very efficient inspection of the buses just previous to their leaving the garage. The man assigned to this inspection is held strictly responsible for failures while the vehicle is in service.

Before a bus is scheduled to leave the garage, one of these door inspectors examines it from radiator cap to tail-light, making any minor adjustments required. If he should find any indication of a possibility of trouble in service, another bus is substituted and repairs are made before the vehicle again goes into service. In some cases the foreman in charge of the garage is called, and, after consulting the inspector and making an examination himself, decides that the bus is fit to complete the run to which it is assigned and makes arrangements to have the necessary repairs or replacements made upon its return to the garage.

The chart in Fig. 7 shows the total number of miles

(*Concluded on p.* 106)

Essentials of Motorcoach Maintenance

Transportation Meeting Paper

By L. V. Newton [1]

AFTER reviewing motorcoach history and outlining the transition period of development, the author says that operation and maintenance go hand in hand, but too much stress is placed on maintenance methods and not enough on operation. He has yet to find a transportation superintendent who makes motorcoach operation a subject of paramount importance, although the manner in which the coach is driven may decide whether that particular coach makes money or loses it.

In the author's opinion, the success of any coach and its freedom from repairs are dependent upon how well the driver knows how to drive it and, secondly, upon systematic lubrication and scheduled maintenance. The selection and training of drivers is a function of the transportation department, and too much stress cannot be laid on these functions and on continuous close supervision so that the department is certain that the vehicles are driven correctly.

The author advocates that all drivers spend two weeks in the repair shop before assuming their duties as operators, and also that drivers' fitness as operators be passed upon by the maintenance department before the drivers assume their positions. He suggests also that, when selecting transportation inspectors or supervisors, men having a mechanical background be chosen so that they may be better qualified to note carelessness and abuse of the vehicles by the driver and to report intelligently on the vehicles' defects when they ride in the motorcoaches.

In conclusion, the author remarks that passengers represent the income of the coach business, because without passengers there can be no income. Profits are measured by the difference between income and the expense of operating coaches. The expense, therefore, is equally as important as the income. Consequently, as much effort should be made toward keeping the expense low as in keeping the income high. Eternal vigilance is the price of low-cost maintenance. No maintenance is good unless it is systematic, because, otherwise, important items are sure to be overlooked. In the organization of the system it is necessary that the buildings, equipment, men and management all be combined to produce one result; namely, keeping the fleet in running order at the minimum cost.

IT WAS ONLY about 10 years ago that some electric railways began to operate motorcoaches. Into a well organized and somewhat conservative industry was injected a new form of transportation possessing both advantages and disadvantages as compared with the street-car. Compared with an electric street-car, the early "bus" was of flimsy construction and in a development stage. Small wonder, therefore, that it was at first not well received by street-railway men. Further, immediately prior to its adoption, the railways had been waging a battle against the interloping "jitney" motor-vehicle, and this controversy had not served to better the feeling of street-railway men toward the motorcoach.

Many of the earlier motorcoach installations by electric railways were undertaken solely to eliminate jitney competition, or to develop feeder-line service into newer residential districts; and few of these earlier projects could be justified from an earning standpoint. Railway executives, under these conditions, were for the most part indifferent and even hostile to their own motorcoach lines. Under the circumstances, the men in actual charge of maintenance received little help or encouragement in the solving of the myriad problems with which they were confronted. The unsystematic methods of maintenance employed during the early years of motorcoach operation were, I believe, partly due to lack of understanding and lack of interest on the part of street-railway management.

Non-standardization of motorcoaches has, from the beginning, added much difficulty to the maintenance problem. About 1923, a large number of manufacturers marketed so-called motorcoaches and sold them in considerable numbers throughout the country. Many of these vehicles were passenger-car chassis with elongated wheelbases, or else were truck chassis. Executives naturally found it difficult to decide upon any one make which impressed them as being outstanding. Hence they purchased several makes, possibly because they thought that, by operating a few of each make, they would find out for themselves which make was the best.

Faulty design, inadequate powerplants, poor brakes, truck-type springs, and poorly built heavy bodies with high center of mass characterized most of the earlier models, and this tended toward maintenance difficulties. To aggravate the problem still further, those in charge of maintenance were called upon to use sections of car barns or sheds as motorcoach garages and repair shops, usually without heat or adequate lighting, and having a floor plan totally unsuited to the movement of large vehicles. Adequate tools and shop equipment were usually conspicuous by their absence.

Another thorn in the side of the maintenance man was the lack of satisfactory personnel in the operation and the maintenance departments. In the early days of this industry, drivers were recruited either from the street-car company or hired from outside sources. Usually they had no training as coach operators, and little or no attempt was made to train them properly. Likewise, garage personnel was largely untrained, usually being hired from automobile or truck service-stations or from garages, and sometimes from street-railway-company shops. This picture is certainly not a bright one, yet I believe that the points brought out are the probable reasons for much of the faulty practice which developed in the operation and the maintenance of motorcoaches, and that not until these faults were corrected did motorcoaches win their proper acceptance by the transportation industry.

[1] M.S.A.E.—Byllesby Engineering & Management Corp., Chicago.

Changed Methods Noted

During the last several years the situation has changed. It seems that the motorcoach is receiving its rightful recognition; further, that all phases of its operation and maintenance are being studied and systematically improved.

Motorcoach operation and maintenance go hand in hand, and ofttimes I believe that too much stress is placed on maintenance methods and not enough on operation. To illustrate, the larger coach-companies usually have a transportation department, the head of which is responsible for the selection and training of drivers and the operation of coaches; and a maintenance department, the head of which confines his attention to the maintenance of the coaches under his supervision. The transportation department is prone to interest itself primarily in operation, seeing that drivers of coaches treat the public courteously, run on time, and make proper accounting of fares collected, all of which are of great importance. I have yet to find a transportation superintendent who is making the driving of the coach a subject of paramount importance, yet the manner in which the coach is driven may be the answer as to whether or not that particular coach makes money or loses it. The success of any coach and its freedom from repairs is dependent upon two things: first, how well the driver knows how to drive it; second, upon systematic lubrication and scheduled maintenance.

Need for Driver Training Stressed

The selection and training of drivers is a function of the transportation department, and too much stress cannot be laid upon the wise selection and the proper training of drivers, as well as upon close driver-supervision all the time to be certain that the vehicle is driven correctly. I advocate very strongly that all drivers spend two weeks in the repair shops before assuming their duties as drivers, so that they will become at least partly familiar with the mechanism of the vehicle which is to be entrusted to their care. I also advocate that, before drivers assume their positions, their fitness as drivers be passed upon by the maintenance department.

It is further suggested that, in selecting transportation inspectors or supervisors, men with a mechanical background be chosen so that they will be better qualified to note carelessness and abuse of the coaches by the drivers, and be able to report intelligently on mechanical defects when they ride on the coaches.

The foundation of any coach company is its vehicles and drivers. They may be considered together as a unit, for it takes the motorcoach and the driver acting as a unit to haul passengers. The possibilities of successful operation depend largely upon the manner in which the coach is manned. Had I to choose between poor coaches and good drivers or good coaches and poor drivers, I would take chances on making money with the poor coaches and the good drivers.

Preventive Maintenance Favored

There are two ways to maintain coaches; namely, to make repairs when breakdowns occur or to schedule maintenance operations and thus perform preventive maintenance. In other words, one can call in the doctor when one is sick and unable to work, or one can pay the doctor to keep one well so one will be able to work. The plan I favor is the preventive-maintenance plan with systematic inspection, in that it keeps maintenance cost per mile at the minimum, reduces to the minimum coach-breakdowns and changes, and keeps the coach available for service the maximum number of hours per year.

It is difficult and almost impossible to lay out any standard inspection or maintenance plan that would be applicable to all coach operations, in that the number of coaches involved and the character of the operations must be considered in formulating any plan. It has been my observation that the small coach-company operating say 25 to 30 vehicles usually can show a lower maintenance cost per mile than a larger company can. Part of this is due to elimination of certain overheads that the large company has and the small company does not have. Part of it is due to the fact that, in the small coach-company, those in charge of maintenance of the coaches are possibly in closer contact with the coaches under their jurisdiction and the drivers may be under closer supervision.

The small coach-company should have a maintenance scheme that includes periodical inspection. By this is meant that at stated mileage-periods in the life of the coach it should be thoroughly inspected. At this time oil in the engine crankcase should be changed, lubrication in the transmission and rear-axle housings checked for level or changed, the entire chassis thoroughly greased, the coach thoroughly cleaned both inside and out, and the necessary mechanical work performed.

It is usual to find that an inspection report-form is used; this the mechanic performing the inspection is required to fill in. Some of the reports which have come to my notice are nothing more or less than lists enumerating all the parts of the motorcoach, with a column beside the names of the parts for the mechanic to place a check mark in, indicating the condition. I do not favor this type of report. I feel that the mechanic should be provided with a form which indicates exactly the work performed. In other words, instead of using a form that simply lists the items such as, "Spark-Plugs," the form should state, "Remove, clean and adjust spark-plugs." If an inspection form is used, and I believe this is necessary, then it should instruct the mechanic just what he is expected to do.

Plan for Large Companies Stated

The following plan is used in one of our larger coach-companies. The drivers of coaches report daily on a defect card any trouble they have had with the coach or any difficulties that they believe should be corrected. The inspectors who ride the coaches make notes on the same card regarding any points which they believe should be corrected. These cards are sent to the maintenance-superintendent's office. After being noted by him, they are passed on to the garage foreman, who checks the need for the work. He verifies the accuracy of the report and arranges for the work to be done if it is found to be necessary.

After each 1500 miles of operation, each coach is inspected at night. Here, again, we find a routine being followed whereby engine oil is changed, the level of lubrication in transmission and rear-axle housings is checked, the coach chassis is thoroughly greased, the coach is cleaned inside and out, and all necessary work is done. Should it be found that time does not permit making all needed repairs but that the coach can

still function properly, it is returned to service and other needed repairs are made as soon as possible.

Elaborating on the cleaning of coaches inside and out, at the same time this cleaning is done the engine is steam-cleaned to remove accumulations of dust and grime. This is of the utmost importance because, by cleaning engines at inspection periods, they are kept fairly clean all the time and mechanical work can be performed with greater efficiency. Cleaning also calls for the replacement of window drapes if necessary, and spare drapes are kept on hand, the fresh drapes being installed and the old ones removed, cleaned, and placed in stock for future use.

Close attention must be given to the condition of the seats. Careless inspection here often results in soiled or torn clothing and, aside from the discomfort caused passengers, results most times in damage claims the cost of which are far greater than those caused by proper inspection and cleaning. Ceilings are also washed at inspection periods if they require it. The ceilings of most of our coaches are finished in ivory, and nothing is more unsightly than a dirty ceiling.

General Overhaul Procedure

Regardless of how well coaches are oiled and greased and maintained generally, a time comes when a general overhauling must be done to rehabilitate the vehicle and restore it to approximately its original new condition. The overhauling should be scheduled just as the inspection periods are scheduled; but I believe that it is impossible to lay down any standard mileage figures at which overhauling becomes necessary, because of the varying conditions in each operation.

In one of our large companies, scheduled overhauls are called for at from 50,000 to 75,000 miles, depending on the type and make of coach. Where coaches are standardized the unit system of handling repairs may be used, thus shortening the overhauling period. Having available rebuilt engines, transmissions, clutches, relined brake-shoes, rebuilt differential-carriers, generators, starters, ignition heads, and numerous other units, reduces to the minimum the time the coach is laid up for overhaul.

The unit-repair system also enables operators to determine the length of time each respective unit can be kept in service efficiently. If it is found that the rear-axle carrier will as an average give continuous satisfactory service for a given number of miles and at the end of this period cause trouble, it is good practice to remove all carriers for inspection after they have been in service for this mileage, regardless of their condition, thus eliminating failure of the part on the road. An analysis of failure over a period of time will indicate which parts wear the longest with the least amount of maintenance attention, and will also show whether the number of such failures are caused by careless driving, poor inspection or poor material.

With the unit-repair system it is also relatively easy to set up inexpensive testing-machines to assure the proper functioning of each particular unit before it is placed in a vehicle. This eliminates the possible need for removing it a second time, which is very often necessary when repairs are made to the unit while it is in the chassis. Very few mechanics who overhaul an engine can await without misgivings the starting of that engine to determine whether it will operate satisfactorily.

Dynamometer Tests and Other Practices

If an operation is large enough to warrant it, a dynamometer is a profitable investment, as it permits engines to be thoroughly tested before being placed in the chassis. When the coaches are overhauled mechanically, necessary body repairs are made and the coaches are painted as they require it. In all of our coach operations, overhauling and painting work is done by the same corps of shop men who are responsible for the maintenance and overhauling of passenger-cars and motor-trucks belonging to the company by which the coaches are operated. I am strongly in favor of this, because the coordination of passenger-car motor-truck and motorcoach work precludes the duplication of repair-shop buildings, equipment and personnel. In many cases it makes possible the furnishing of tool equipment for the use of all that would not be possible if coaches were maintained separately.

The number of mechanics, washers, greasers, and cleaners needed to maintain a given fleet of coaches is much of a moot question. It would be most desirable, were it possible, to devise some formula for the guidance of all operators, so that each could know that the manpower employed was ample but not excessive. But so many variables enter that I believe each operation must be studied individually and the correct solution derived for each.

It would be interesting if all operators would prepare a table or curves showing the number of "labor hours" employed for maintenance and garage operation per 1000 miles of coach operation. In the preparation of such tables or curves it is suggested that labor hours include maintenance superintendence, maintenance of coach bodies, maintenance of coach chassis, changing of tires on the road, maintenance of shop and garage equipment, maintenance and operation of service cars, miscellaneous shop expense, fueling coaches, oiling and greasing coaches, garage employes, garage supplies and expense. Comparative tables of maintenance personnel would be of great value to all operators, and the information could be compiled easily.

Type of Shop Needed

In no other business is the kind and type of building more important than in the case of a motor-vehicle and motorcoach repair-shop. In many cases the buildings which we are forced to use are not adapted to shop purposes for various reasons. In such cases it is usually necessary to move the vehicles time after time while they are in the repair shop. Aside from being inconvenient, it has proved to be expensive.

A successful maintenance station requires, first, proper location; second, proper lay-out; third, proper equipment. The location may of necessity not be ideal, inasmuch as many factors govern it over which the operator has no control. Whenever possible, the entrance should be on a street on which there is no street-car line and little traffic. The type of operation, size, lay-out of routes and land values determine to a large extent the location of the maintenance station. The best repair shop, however, should be as centrally located as possible with respect to the districts served, to reduce dead traveling-time to the minimum.

In regard to lay-out, separate entrance and exit should be provided wherever possible, to avoid narrow passages and turns and give easy access to all parts of the shop. The sooner a vehicle can be moved to the

shop or storage room, the sooner another can enter. This avoids parking them in a temporary place until the proper space is made available. A one-story building with all activity on the ground floor is ideal. Land values, however, sometimes make it necessary to build a 2 or 3-story building, in which case electric elevators or ramps must be used. A suitable wash-rack should be located near the entrance door, so that coaches may be cleaned before proceeding into the repair shop.

Daylight is an important factor. No shop should be laid out without giving lighting most serious consideration. Shop auxiliaries such as toolroom, machine-shop, stockroom, battery room and tire room should be centrally located to avoid waste effort. Where these activities can be placed adjacent to one another, this plan works out very well. Elaborate machine-shops seem to me to be no longer necessary, as most parts can be purchased from the manufacturer ready to install. Expensive machine-tools are needed only for the building of special parts or the reclamation of worn parts.

The size of the operation governs the amount of equipment that should be placed in a machine-shop. I feel, however, that machine-shop work should be limited to refacing valves, relining brakes, use of the boring-bar for main-bearing work, connecting-rod cutting-tools for connecting-rod-bearing work, and necessary reamers for piston-pins and bushing work. In general, in addition to these tools, a lathe sufficiently large to handle brake-drums, a drill-press for miscellaneous work and an emery-wheel stand for tool sharpening are essential. A cylinder grinder might also be warranted.

With reference to the toolroom, study should be made of various special wrenches, speed wrenches and wheel pullers which are applicable to the coaches to be maintained. Such tools will save labor and will pay for themselves if used. The toolroom should be sufficiently convenient to the repair shop so that mechanics will not lose time in going to and from the toolroom. A good check-system is indispensable, because it reduces the expense of lost tools and also calls to the immediate attention of the man in charge of the toolroom that tools are out. At the end of the day he can get them back into the toolroom if they are not returned by the men promptly.

The stock room should be large enough to store properly an adequate stock of repair parts and supplies. Modern steel-bin equipment for storage of parts is fireproof, movable, neat in appearance, conserves space and makes it easier to take inventory. Its partitions are easily adjustable, so that openings can be provided for various sizes of parts. A good inventory-control should be established to provide a safeguard against surplus, obsolescence or shortage. The amount of stock which should be carried is entirely dependent upon the size of the operation, the make and type of coaches operated and the location of the stock room relative to the source of supplies. No more money should be invested in repair parts and supplies than is essential; on the other hand, the stock should not be so limited as to tie up coaches waiting for parts.

Considerations Regarding Personnel

Building layout and equipment are important, but garage and repair-shop personnel governs to a great extent the quality of the work performed and its cost. A good maintenance superintendent with the right kind of an organization can secure better results with a poor building and little equipment than can an inefficient superintendent with the most modern building and elaborate equipment. If an operator intends to build a new garage and repair shop, he should spend a great deal of time studying plans and specifications, and spare no effort to make sure that the new layout will be most modern and efficient. It is just as necessary to give deep thought to the garage personnel. Every time a man is hired, promoted or given added responsibilities, an organization is being built up.

A maintenance superintendent should have the ability to select the right man for the right job, bearing in mind that the selection has not alone a direct bearing on the work to be performed but also upon the morale of his whole organization. This superintendent also must possess executive ability, which to me means a man who is able to get things done by others in the shortest time in the smoothest way and in the right way. A man may have good organizing ability, and be a poor executive. Organization is the machinery, executive ability is the power that runs it.

A shop foreman must be a good mechanic, know intimately the vehicles in the fleet and be able to maintain a high standard of workmanship. He must be able to handle men, plan work and know what constitutes shop expenses. He must possess loyalty, which he can and should practice and preach to his men.

Two ways exist for securing mechanics for garage and shop personnel. First, hire them from outside garages or companies; second, develop them by systematic training. Where at all possible, I believe the most satisfactory method is to train the men. Mechanics should be convinced that they constitute a very important part of the organization. They should be treated with consideration, and some interest should be taken in their personal affairs if they request assistance. A dissatisfied man will do one or more of three things; become careless in his work, start trouble among others, or quit. Any one of these is expensive.

A company operating motorcoaches makes money or loses it in accordance with the way its internal affairs are handled. If the selection of the routes has been correct, the number of passengers being carried is dependent on weather conditions and other factors beyond the control of the operator; but, this natural flow of the public to the operator's motorcoaches will depend on other factors directly controlled by him.

The appearance of the coach, which includes cleanliness within and without, the manner in which it is driven, the condition of its paint, the type of lighting, the type and make of equipment used and general design of the body, will all have their effect on originally selling the idea of using the coaches to patrons and influencing them to be riding in them continually.

Passengers represent the income of the coach business. Without passengers, there can be no income. Profits are measured by the difference between income and the expense of operating the coaches. The expense, therefore, is equally as important as the income. Consequently, as much effort should be made toward keeping the expense low as the income high.

Eternal vigilance is the price of low-cost maintenance. No maintenance is good unless it is systematic, because important items are sure to be overlooked. In the organization of the system it is necessary that the buildings, equipment, men and management all be combined to keep the fleet running at minimum cost.

Possibilities *of* Low-Grade Motor Fuels Overestimated

Milwaukee Section Paper[1]

By Robert E. Wilson[2]

INTEREST in low-grade motor fuels is perennial, scarcely a month having passed in the last ten years that someone did not come out with a new device which was claimed to make possible the utilization of lower-grade fuels in internal-combustion engines. In my experience, however, these inventors and other proponents of low-grade motor fuels are generally inclined to greatly overestimate the advantages and to overlook certain important disadvantages inherent in the use of such fuels.

Price Differential 3 to 5 or 6 Cents

The outstanding advantage claimed for the use of low-grade fuels is their lower cost, but cost comparisons are commonly made by comparing wholesale tank-car prices for low-grade fuels with service-station prices, including tax, for gasoline. The fundamental difference in the costs of these two fuels is, however, much less than such comparisons would indicate, as may be seen by referring to the tank-car prices of various fuels in Oklahoma.

The average difference in price between United States Motor Gasoline and kerosene during the last three years, as calculated from figures in the Oil Price Handbook, was 2.39 cents per gallon, and the average difference between motor gasoline and gas-oil, which is heavier and less well refined than most furnace oil, was 4.66 cents. These small differences are not at all unreasonable in view of the fact that gas-oil or any similar light distillate can be converted by cracking at comparatively low cost into about 75 per cent of gasoline and 25 per cent of gas-oil and fuel oil.

While freight rates on the lower-grade fuels are slightly less than on gasoline, the cost of widespread distribution of such a fuel in service stations would be higher than that for gasoline on account of the much smaller demand. Although furnace oil can be distributed in cities by tank wagon at rather low cost because the unit deliveries are large and hauling distances are small, this would not apply to general service-station distribution. Barring the question of gasoline taxes, which would probably be extended to lower-grade fuels if they came into widespread use, it may be said that the normal price-differential between gasoline and kerosene under present conditions is only around 3 cents per gallon, and that between gas-oil and gasoline is a matter of 5 or 6 cents per gallon. Since the average automobile consumes about 500 gal. of gasoline per year, this would mean a difference of only $15 to $30 in the average motorist's yearly fuel bill. Such a small saving certainly affords little margin on which to overcome the many difficulties connected with heavy-oil utilization, especially in passenger vehicles.

[1] Supplementary to paper on Significance of Tests for Motor Fuels by the same author presented at the same meeting and published in the S.A.E. JOURNAL, July, 1930, p. 33.

[2] M.S.A.E.—Assistant to vice-president in charge of manufacturing; head of development and patent department, Standard Oil Co. (Indiana), Chicago.

Inventors and other proponents of low-grade motor fuels, asserts the author, are prone to overestimate the advantages and to overlook the important disadvantages inherent in the use of such fuels in engines for motor-trucks, motorcoaches, airplanes and motorboats.

A great deal of inventive and development work has been done at great expense on devices for adapting internal-combustion engines for the utilization of the heavier and less thoroughly refined fuels, but none of these has proved generally successful.

Lower cost is the chief advantage claimed for the low-grade fuels, but in the last three years the tank-car price of kerosene has averaged only 2.39 cents per gallon less than for United States Motor gasoline, and that for gas-oil only 4.66 cents per gallon less than for gasoline. Against these price differentials are to be set numerous difficulties and disadvantages of using the lower-grade fuels in passenger-cars, motorcoaches, motor-trucks, pleasure motorboats and airplanes. If specifications were set up to overcome some of these, the cost of refining would largely wipe out the price difference. So would a very large increase in demand if a device could be perfected that would overcome them.

The author discusses the various difficulties with relation to small Otto-cycle engines, Diesel engines, tractors and airplanes. He states that it seems improbable that for passenger vehicles the advantages of heavy fuels can ever outweigh the disadvantages; that thousands of tractors designed to operate on kerosene are being run on gasoline; and that it seems doubtful if Diesel engines can compete with gasoline engines in trucks and motorcoaches. He predicts that for years to come the difficulties and disadvantages in the use of low-grade fuels will outweigh the doubtful savings, as far as passenger vehicles are concerned, and that gasoline of about the present distillation range but of higher antiknock value will maintain its supremacy.

Factors That Would Overcome Price Difference

The fact should also be emphasized that the maintenance of even this rather small price-differential depends upon two factors; first, the absence of any close specifications on products such as gas-oil; and, second, on the demand for gasoline remaining much greater than the demand for gas-oil. On the first point, the low cost of gas-oil is due in part to the fact that almost any clean, light distillate that is too heavy for gasoline can be sold as gas-oil or furnace oil, and therefore the products put out by different refiners vary rather widely in their characteristics. Some furnace oils, for example, happen to have rather good antiknock properties, but as soon as a rigid antiknock specification, or a gum or sulphur or odor specification is insisted upon, the cost of refining would go up and the potential supply of such fuel would greatly decrease. Both of these factors would result in a relatively higher price for such a special low-grade fuel.

As to the importance of the relative demand of gasoline and gas-oil, it must be remembered that, while gas-oil can be converted very largely into gasoline, the reverse is not true, and, if the demand for gas-oil should outstrip that for gasoline, the price of gas-oil might go well above that of gasoline, as was the actual situation in the industry for many years. Also, even these moderate savings in fuel costs depend upon the ability to operate engines on the heavier fuels at as high compression-ratios and with as effective mixture distribution as on the lighter fuels. This is by no means a simple matter in Otto-cycle engines, though it can be done in Diesel engines.

Principal Problems To Be Solved

As to the general tendency to underestimate the difficulties of utilizing heavier fuels, most workers in this field seem to assume that the primary problem is to distribute and burn the fuel. Actually, however, dozens of devices are available that are reasonably satisfactory for the distribution and combustion of heavy fuels once the engine is warmed up. The principal problems to be overcome are, in reality, those of starting, detonation, crankcase-oil dilution and odor. The starting problem alone makes heavy fuels unsuitable for ordinary passenger-car service; and, while it can be overcome by a variety of expedients, all of them are troublesome and time-consuming.

As to detonation, most kerosene-burning engines, outside of California, have had to be designed for a substantially lower compression-ratio than would be suitable if gasoline were the fuel, and the resulting loss in efficiency frequently almost neutralizes the difference in cost of the fuels. It is true that some kinds of furnace oil have fairly good antiknock properties, but the higher-boiling straight-run products generally knock much worse than gasoline, and an engine that is to be run on low-grade fuel must necessarily be prepared to handle the general run of such products.

The third difficulty that is frequently overlooked is the excessive dilution of the crankcase oil which occurs with the heavier fuels and which makes their use for intermittent operation, particularly in winter, almost out of the question. Another difficulty, which is serious for passenger-car use, is the unpleasant and penetrating odor of the heavy fuels and the fact that if any is spilled about the car or on the clothing the odor persists for a long time. Also, many heavy fuels, if used continuously, will give trouble because of the presence of high sulphur or gum content.

The importance of some of these difficulties depends to a considerable extent upon the use for which the engine is intended. For tractors which are to be run steadily over long periods, the factors of odor, starting and crankcase dilution are relatively minor, although the problems of detonation and gum still exist. Here, too, the high fuel-consumption increases the incentive to use heavy fuels, although thousands of tractors supposedly designed for kerosene are run on gasoline in spite of its higher cost. In any case, it seems improbable that, for use in passenger vehicles, the advantages of heavy fuels can ever outweigh the disadvantages.

Difficulties of Use with Otto-Cycle and Diesel Engines

For use of heavy fuels in Diesel engines, some of these difficulties are eliminated, but others crop up. Detonation and crankcase-oil dilution are no longer matters of moment, but odor, gum, lubrication, smoky exhaust, low-temperature starting and other difficulties are of similar or greater importance. Also, the much higher first cost of the Diesel engines, especially those of automobile size, more than outweighs any probable saving in cost of fuel. For airplanes, where engine sizes are relatively large and minimum fuel-load and fire hazard are of great importance, Diesels may be able to compete, but whether they can effectively compete in trucks and motorcoaches seems quite doubtful, at least in anything like their present stage of development. In motorboats for pleasure use the hours of service per year are generally too few to justify the higher first cost of Diesel engines. Furthermore, even in the case of airplane engines, if they are adequately cooled and use a fuel of really high antiknock value—preferably a fuel having good natural antiknock properties, to which substantial amounts of tetraethyl lead have been added—it is possible to obtain as great or greater horsepower per pound of fuel than from any airplane Diesel engine thus far developed.

The common idea that Diesel engines are extremely flexible in the fuel they can use is not true as regards the smaller Diesels suitable for airplanes, trucks and motorcoaches. The larger slow-speed Diesels with air injection will run on a rather wide variety of fuels, but the small engine of the solid-injection type is usually limited to the general range of gas-oil and kerosene. Lighter fuels give trouble with pump lubrication, vapor lock, and high ignition-temperatures, and heavier fuels, particularly residuum fuel-oils, seem to be out of the question. Almost any Diesel engine can run for a short time on heavy oils, but incomplete combustion and gradual accumulation of deposits are almost unavoidable in small engines. Also, gum, dirt and water are in general more serious in solid-injection Diesels than in ordinary engines, and low-grade fuels are more likely to carry them than is gasoline.

Although the rôle of the prophet is proverbially profitless, I venture the prediction that for many years to come the serious difficulties and inconveniences involved in the use of low-grade fuels will outweigh the doubtful savings in total cost, at least as far as passenger vehicles are concerned; and that gasoline of a distillation range similar to the present, but of higher antiknock value, will maintain its supremacy as the standard fuel for internal-combustion engines.

THE DISCUSSION

J. B. FISHER[3]:—The demand for lower-grade fuels is hard to analyze. Mr. Wilson has shown that the cost differential in the different fuels in the field is only about 3 to 5 cents per gallon, yet, from the demand that comes from some quarters for low-grade fuels, one would think there was a difference of $5. When we get down to the bottom of it, we wonder just why this demand for lower-grade fuels keeps cropping up when the saving is only a matter of a few cents per gallon. We feel that it is largely psychological; that people get the idea that they can save considerable money on fuel, whereas, if they would analyze the investment and upkeep of equipment necessary to handle the lower-grade fuel, quite often they would find that little if any saving is to be made.

One odd twist is that contractors, largely, like a lower-grade fuel for the reason that they find that their employees cannot burn it in their cars. That may sound funny, but it is true. A contractor operating six shovels and about 20 trucks, told us on a certain occasion not long ago that he estimated that not less than 25 per cent of the gasoline he purchased went into the cars of his various employes. He tried all kinds of methods of keeping tab on the gasoline, but the men would always find some way of getting around them and getting gasoline for personal use. This, I think, is a sound reason. If a person has a gasoline bill of $1,000 or $2,000 per month and 25 per cent is getting away from him, that is a considerable item.

A tremendous amount of money has been spent in the development of lower-grade-fuel devices. A company not far from Chicago spent $750,000 in the last two or three years on devices for burning low-grade fuel. It has not marketed any of them yet, after putting all that time and money into them, and, as far as the outsider can see, the company is as far from a solution of the problem as it was five years ago.

Undoubtedly the lower-grade fuels will be used in Diesel engines, with a substantial saving, when there is a great deal of horsepower to be used in the course of a year. We have been able to operate our Diesel engine at Waukesha on a considerable range of fuels having a gravity of 23 to 40 deg. Baumé without changing adjustment of any kind.

Vaporization and Combustion Problems Relatively Easy To Solve

R. E. WILSON:—I am quite in agreement with Mr. Fisher on the matter of money expended on devices for burning low-grade fuels. It is really amusing. I do not mean to say that in some special cases, for example, airplane uses and possibly some few others, the idea may not have some value behind it, but our information system receives on an average of at least once a month an announcement of some new, improved carburetion-system or fuel pump that is claimed to handle heavy or crude oil. I do not know why the inventors want to burn crude oil, with all the wax and lubricants it contains, but the idea always sounds good. Crude oil is generally more expensive than the heavier fuel oil made therefrom. Also about once every three months we see an announcement of a new process of vaporizing heavy fuels. I know of at least five concerns that have spent anywhere from $100,000 to $1,000,000 on this idea, yet not one of them has come out with anything that is commercially successful.

The problem looks intriguing, particularly when the tank-car prices of heavy fuels are compared with the service-station price, including tax, of gasoline. Most inventors start with the idea that all they have to do is to vaporize and burn the fuel, but that is the smallest end of the problem; dilution, detonation and those other difficulties are the real big problems.

Tractor-Engine Operation on Distillates

L. F. OVERHOLT[4]:—Have you had any experience in testing different cuts of distillate having a rather short distillation range, say, of approximately 200 deg. between initial and end-points?

MR. WILSON:—If the 10-per cent point is right, and the 50 and 90-per cent points are below the limit, those fuels are perfectly satisfactory. I do not believe they are appreciably better than regular gasoline, but they would be more expensive. If, however, the narrow range is in the upper half of the ordinary gasoline boiling-range, you cannot get a 10-per cent point that is right for easy starting.

MR. OVERHOLT:—I was thinking of distillates or furnace oils, rather than of gasoline. In that case, the 10-per cent point would be eliminated and you might have an initial boiling-point somewhere in the neighborhood of 375 deg. fahr. and an end-point of probably 575 deg.

MR. WILSON:—Such a fuel could be distributed and burned satisfactorily in a well-designed heated manifold with moderate compression pressure, but you would still have the problems of starting, odor, crankcase-oil dilution and so on.

MR. OVERHOLT:—Our experience with tractor engines is that Stanolind furnace oil is much more easily handled than kerosene; we do not have the trouble of detonation and, as a matter of fact, we get less crankcase-oil dilution.

MR. WILSON:—There is no necessary relation between the two properties to the best of my knowledge. In general service, heavy fuels detonate worse and dilute more than lighter ones, but dilution is purely a physical effect due to the heavy ends of the fuel, which are not volatile enough, whereas detonation is a chemical characteristic of the fuel as a whole. Some high-boiling fuels detonate badly and some do not, but they all dilute worse than low-boiling fuels.

Export Trade Affected by Gasoline Price

MR. OVERHOLT:—Another point about this price differential: I do not think we are so much concerned with the domestic situation; the oil companies have got their price differential down to where it does not cause an alarming situation, and, as you say, they promise us even less in case the lower-grade fuels could be burned; but what are we to do about the export engine? In many countries, if the purchaser has an engine of more than 3 or 4 hp., he is much concerned with the price of gasoline, especially where the price runs, as it does in

(*Concluded on p.* 106)

[3] M.S.A.E.—Chief engineer, Waukesha Motor Co., Waukesha, Wis.

[4] Aff. Rep. S.A.E.—Research engineer, tractor division, Minneapolis-Moline Power Implement Co., Minneapolis.

Practical Tractive-Ability Methods

Discussion of Austin M. Wolf's Transportation Meeting Paper[1]

SOME discussers commend the method set forth by Mr. Wolf as being concise, easy to apply and of great practical value to heavy-vehicle operators for specifying the ability they want in vehicles when making purchases. Others raise objection to the use of torque figures rather than horsepower in the formulas, and one discusser points out that operators are primarily interested in knowing the grades that a vehicle can climb at given speeds. He refers to the use of a simple accelerometer for making tests and believes it is possible to provide the operator with all the information he needs in graphic form, so that he need not make any computations. A motion recommending the appointment of a committee to study the matter and report what information vehicle makers should furnish in their specifications was carried.

Much of the discussion is concerned with the efficiency of transmissions and rear axles, road and tire resistances, and with the desirability of calculating tractive ability from horsepower.

The author and others point out that the purpose in using torque in the formulas was to reduce the problem to its simplest terms and present a yardstick by which the operator can determine the facts he wants without going out on the road and securing values by means of instruments.

ADRIAN HUGHES, JR[2]:—I think that Mr. Wolf has given a very concise and easily applied method for comparing the performance of different vehicles, and the direct way in which he has handled the subject and the references he has given show that those conclusions should be of great practical value.

In considering the tractive factor, he mentioned the fact that greater engine-torque increases performance but that increase in the size of the engine is limited by the original design of the transmission facilities in the machine. Experience in Baltimore has forcibly brought that out. We had some 55-passenger double-deck buses, originally equipped with four-cylinder sleeve-valve engines of about 320-cu. in. piston displacement. Because of the increase in the number of passengers riding and the traffic congestion, it was found difficult to keep up the schedule with that powerplant. We decided to increase the size of the powerplant and were able to secure some second-hand six-cylinder Buda engines of about 387-cu. in. displacement.

ADRIAN HUGHES, JR.

The result of the substitution was very satisfactory from the point of view of making better time, as the vehicles were more flexible, and some improvement in the gasoline consumption with the larger engine was noted, but we soon encountered some of the difficulties referred to by Mr. Wolf. First, a left-hand jackshaft broke off clean, and then we had considerable trouble with the gears in the rear axle. So, while we got away from engine trouble and improved the performance of the vehicle, we got into trouble in transmitting the additional torque.

These buses have now been replaced with new ones. Comparative figures on the ton-miles per gallon of gasoline show that during August, 1929, the vehicle-miles per gallon with the old buses was 3.6, and the miles per gallon in August, 1930, after the replacement with the present buses, was 2.1 miles per gallon. The weight of the old double-deck buses was 12,000 lb. and the average number of passengers was 16.5, at 150 estimated pounds per passenger. The weight of the new double-deck buses was 25,000 lb., and the average number of passengers per bus per trip increased to 19.4, at 150 lb. On that basis, the ton-miles per gallon of the old double-deck buses was 26, and that of the new ones was 29.3.

Efficiency Figures Revised from Road Test

A. J. SCAIFE[3]:—Several years ago we were using an efficiency of 85 per cent in high gear and of 75 per cent in low gear through the conventional transmission and axle. The efficiency was decreased about 5 per cent for each additional transmission unit, such as an auxiliary transmission or an additional driven rear axle.

To check these efficiencies we connected a drawbar dynamometer between a truck and a trailer, both loaded to capacity, and made several check runs. A test was made over a piece of level brick pavement, check runs being made in both directions. A truck of each model capacity was used, and efficiencies up to 97 per cent were obtained in high gear and 92 per cent in low gear. The engine torque was taken at a point on the curve with a straight line drawn from 800 to 1200 r.p.m. and, based on these results, we decided to use an efficiency of 90 per cent in high gear and 85 per cent in low gear.

These results were secured from a series of full-ball-bearing trucks and the efficiency can be duplicated today with trucks equipped with roller-bearings, as the efficiency of the bearings today is about equal. The tractive factors of 0.078 in high gear and 0.338 in low gear, as given in C. T. Myers' paper[4] several years ago, were set up for soft going and at time when three-speed

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[1] Presented at the Transportation Meeting in Pittsburgh, Oct. 23, 1930, and published in the December, 1930, issue of the S.A.E. JOURNAL, beginning on p. 655. The author is an automotive consulting engineer in New York City, and a Member of the Society.

[2] M.S.A.E.—Superintendent, bus transportation, United Railways & Electric Co. of Baltimore, Baltimore.

[3] M.S.A.E.—Consulting field engineer, White Motor Co., Cleveland.

[4] See TRANSACTONS, part 1, 1913, p. 103; also TRANSACTIONS, part 2, 1914, p. 122.

transmissions were used. The high ability-factor was used in high gear so as to have the required ability in low gear without too great a gear spread in the transmission.

An ability factor in high gear of 0.03 can now be used on improved highways with very good results, deducting 0.015 for road resistance. This is a very good average figure for all hard-surfaced highways. In low gear, the required factor is secured by four, five and seven-speed transmissions together with auxiliary transmissions.


M. C. HORINE

A. K. Kenerson, of the Standard Oil Co. of Ohio, has a four-cylinder truck with tank and two four-wheel trailers operating in fairly level country. If one figures the ability factors on this truck equipment, the factor will be zero; in other words, the truck will not move. I was informed a few days ago that the truck train had not missed a trip in 40 days of continuous operation, and it is an old-model truck. So it is ofttimes possible to start a truck rolling through the lower gear-ratios and maintain a fairly good speed on the level with a zero ability-factor.

M. C. HORINE[5]:—The paper by Professor Lockwood, of the Sheffield Scientific School, on Chassis Friction Losses, which is listed in the bibliography with Mr. Wolf's paper, contains an explanation, I think, for the remarkable effects Mr. Scaife has given us. Professor Lockwood indicated that the efficiency losses should not be figured in percentage but in horsepower. He states that if a greater torque is impressed upon a given transmission the loss will not be in proportion to the increase in work done but will be more nearly a constant.

To cite a case in line with Mr. Scaife's testimony, in April, 1929, we made some tests at our proving grounds at Aberdeen, Md. The instrumentation was probably the most elaborate that has ever been used for that purpose. The results, when analyzed, were very confusing. We worked them back against the original data and forward from the original data to the supposed result, and in some cases they did not check at all. In one case, working back to an efficiency figure, we found that our trucks were 135 per cent efficient.

Operator Wants to Know "Gradability"

THOMAS S. KEMBLE[6]:—I should like to raise a question with regard to the statement in the paper that engine torque rather than horsepower is what interests us.

The paper deals particularly with the tractive factor, which is taken from the maximum engine-torque, and everything is worked back from that through the gear ratio. It seems to me that what the operator wants to know, in the final analysis, is the gradability of his machine at all speeds. In other words, a curve showing the gradability of his machine plotted against speed under conditions, say, of a road resistance of 22 lb. per ton would give the operator all the information he wants in very small compass.

A few years ago I undertook, in the absence of suitable instruments, to get this gradability. I presume that now we can get the instruments that are necessary to do this work much more easily. I mounted the instruments that were then available, a speedometer and a stop-watch, on the dash and took motion pictures of the instruments while we were accelerating from a standing start to the maximum speed. Such pictures will give all the information in a single run, and a number of runs can be made so as to check the results. A recording speedometer would give the same results.

I am interested to know whether this method has been followed by any others here and what results they have obtained.

A. M. WOLF:—The purpose of using torque in the paper was to be able to present a simple yardstick that would enable the average operator to reach some conclusion. I agree with Mr. Kemble that, if one were to use numerous instruments and record all the data in a thorough manner, the results in terms of horsepower would give us a complete story. But I used torque to reduce this problem to the simplest terms, to make it unnecessary to go out on the road and try to secure valuations for various speeds and conditions.

MR. KEMBLE:—This paper seems to me to give a practical method for estimating comparative tractive ability rather than for determining it. There is no determination in the paper except on the basis of a number of hypotheses that are subject to considerable variation. I believe it is entirely possible to develop a very simple apparatus that will give the complete answer in a short test. It would be worth studying.

Wolf Method Provides Basis of Comparison

CORNELIUS T. MYERS[7]:—As I understand from Mr. Wolf's paper and his remarks of a moment ago, his method is simply a yardstick to provide a basis for tabulating one's observations.


A. M. WOLF

I started this subject back in 1912 or 1913, tabulating the characteristics of various trucks and obtaining many data on road resistance.

Mr. Wolf assembles the torque and various other factors of the mechanism of the motor-truck and subtracts the road resistance, whatever it may be, and what is left is available for power. That can be checked and has been checked for years back. I remember working many years ago with Mr. Scaife on some road tests along that line.

I have made much use of an accelerometer that I got in England. It is very simple; all that is necessary is to set it level in a vehicle on a level road and when the

[5] M.S.A.E.—Sales promotion manager, International Motor Co., Long Island City, N. Y.

[6] M.S.A.E.—Consulting engineer, St. Louis.

[7] M.S.A.E.—Managing director, Chassis Lubricating Co., Rahway, N. J.

vehicle is coasting the resistance of the wheels on the road plus the resistance in the vehicle can be read on the instrument.

The various factors for efficiencies and so forth which I put down in my paper[8] were only approximate. They have changed some; in fact, they differ slightly for every vehicle. Mr. Scaife stated that the figures given by Mr. Wolf do not seem to apply now, yet I find that the tractive factor, or the ability which engineers give to their various vehicles now, corresponds rather closely with the ability we were trying for back in 1912 and 1913. One purpose of my tests was to show that, with a transmission that had a limited reduction ratio, the vehicle was working at a great disadvantage in operation. The purpose of the change-speed gears was to give the ability to overcome high resistance which was seldom encountered. Experiments were undertaken to show that, instead of having a 3.5:1 to 4.0:1 reduction, we should have had a 5.5, 6.0 or 7.0:1 reduction in the transmission. The large reduction needed was the only excuse for using four or more speed changes.

When I was with the General Motors Corp. years ago it had a design for a truck with a four-speed transmission. The transmission was expensive to build and the truck did not perform well. The reason was that the ratio of reduction between the high speed and the low speed was 2.38:1, and little more effort could be got out of the truck in low speed than in high, particularly in cold weather; it was being used up in the transmission losses.

What an Accelerometer Shows

The accelerometer not only shows the vehicle and road resistances but, when the vehicle is accelerating, the rates of acceleration can be read from it. These rates are the measure of the engine torque less the resistances at the speed when the reading is taken. The effectiveness of the brakes also can be measured by the accelerometer. Formulas are merely yardsticks which, if you have certain data of your own with which to make relative comparisons, will show what you can do in certain directions toward getting better results. If the friction resistances in the vehicle are too high, find out where they are; perhaps the tires are at fault or the brakes drag, or the cause may be the lubricant in the rear axle or transmission. If you want to find the actual resistance of the vehicle, you can get it by means of the accelerometer. From that you can check back by means of formulas. Conditions in one operation are quite different from those in another operation, but you will be able to tabulate the results and get valuable comparisons. When you are purchasing trucks or motorcoaches again, you can indicate to the seller just what you desire and easily check them up in service.

CORNELIUS T. MYERS

[8] See TRANSACTIONS, part 2, 1914, p. 122.

[9] M.S.A.E.—Vice-president, of engineering, Autocar Co., Ardmore, Pa.

B. B. BACHMAN[9]:—While I subscribe to what Mr. Kemble said, I believe another phase of the matter that should be considered is that, unless we are dealing with complete data of horsepower in the form of a curve, our advertising policy usually is to use horsepower at the peak of the curve, which, in most instances, is not the figure that we are interested in from a performance standpoint. On the other hand, if we use the torque without specifying speed, our advertising instincts lead us to use the maximum. This comes at a speed that is within the operating range and is also a very definite measure of the energy created for acceleration, which is one of the most direct measurements of performance that we have. For this reason, I believe that, when we are talking in a more or less informal way without complete specification, our discussions are considerably clearer and lead more directly to results if we use the torque values rather than the horsepower values.

B. B. BACHMAN

Another point that seems to me of great significance and importance in transportation fields at present was touched upon by Mr. Wolf in his paper when he stated that "Greater engine torque would also increase the performance figure; but we know that there is a limit to engine size in view of economy and weight, and the minute we increase it we get a heavier vehicle and the greater W in the denominator partly cancels out the extra torque in the numerator."

I think we have to consider two types of economy; one is absolute, which is the form in which I understand Mr. Wolf to be using it; the other is specific, relating to the earning capacity of the vehicle.

While it is unquestionably true, from the standpoint of the work which Mr. Wolf has outlined, that the law of diminishing returns applies as far as the relationship between the two parts of his formula are concerned, he has not taken into consideration a factor which seems of paramount importance. That is: How far can we go on increasing the performance ability of a vehicle primarily by the power we place in it, accepting the increased specific cost of operation, and still have a margin or an increased return by reason of the greater earning capacity?

The answer probably must come primarily from the men who are operating these vehicles. Based on our ideas of a very few years ago, I think we could criticize most of our designs of today as being uneconomical, but we see from a practical viewpoint that the owners are not only operating these vehicles apparently at a profit but are demanding greater performance ability than we have as yet given them.

I believe that those of us who are engaged in the designing end of the business have not only a great curiosity but a very definite need of knowledge as to how far this tendency is likely to go. The question merits not only such discussion as we can give it in this meeting but also further study by the Transportation Activity Committee of the Society.

Tractive Factor Limited by Tire Adhesion

J. W. SHIELDS[10]:—Tires are one of the most important units to be considered in connection with the tractive factor. Every ounce of power developed by the engine must be transmitted through the tires; they are an integral part of the transmission mechanism.

When using Mr. Wolf's formula we must keep in mind that there are limits beyond which the tractive factor cannot be taken. To illustrate: Mr. Wolf mentions a truck that has a reduction in gear ratio of more than 200:1. I happen to know that when that truck was put on test, loaded to capacity and tied to an object that it could not move, the wheels would turn on the ground when it was put in low gear. Mr. Wolf's formula for calculating tractive effort showed that it has a tractive factor of more than 1, but, practically, it does not have any such factor, because it has exceeded the ability of the tires to adhere to the road.

J. F. WINCHESTER

Another case was brought to my attention some time ago of the owner of a modern very high powered automobile who claimed that his tires were wearing too fast. In checking up on the car, the owner gave me a demonstration of how powerful his car was, by driving along at slow speed in high gear, then stepping on the accelerator and spinning the tires on the pavement. He thought that was a wonderful demonstration of the performance ability of the car. When we loaded the car with four passengers and drove at the same speed over the same pavement, he was not able to spin the tires. Theoretically, according to Mr. Wolf's formula, the tractive factor was less with the load in the car than when the car was empty. Practically, the result of the effort of the engine was greater when the car was loaded, because the tires were pressed against the road surface hard enough to grip it and to translate the power of the engine into movement of the car.

MR. WOLF:—I am glad that you raised that point, which was mentioned but passed over briefly in my paper. The fact that I was not taking into consideration the coefficient of friction of the tires with varying road surfaces, grades and so forth made it necessary for me to presuppose that traction was always possible. It would be desirable to calculate this first, but I felt that was a subject in itself and beyond the scope of my paper.

Simpler Method of Finding Performance Wanted

J. F. WINCHESTER[11]:—The discussion indicates some difference of opinion as to how the matter of truck performance should be presented by manufacturers. Mr. Bachman spoke of the advertising department's method of presenting it. Should it not be considered more from a balanced engineering viewpoint?

We have been in the habit for years, when considering the performance of a vehicle, of obtaining an engine curve that relates to torque and horsepower, and these curves have always been a very interesting and valuable guide. But as we progress, we stick closer to facts and are inclined to look at the matter from a more balanced viewpoint, so the method of presenting the information, as suggested by Mr. Kemble, seems to be highly advisable as compared with present methods.

The present catalog, we will say, shows a horsepower curve and a torque curve. It gives all the specifications, such as tire sizes and transmission and axle ratios, but when the average operator receives that information, he has to go to a great deal of trouble to determine what the actual performance of the vehicle will be in the different gear and rear-axle ratios. If this organization could do some work along the lines indicated by Mr. Kemble, information which we received on individual vehicle performance would perhaps be clearer and of greater value than the present type.

MR. KEMBLE:—The torque of the engine or the gradability of the vehicle does not give sufficient information unless it is coordinated with the vehicle speed. For an operator to know what grade his vehicle will climb is of comparatively little value unless he knows at what speed it will climb that grade. It is possible to provide the operator with the complete answer in graphic form, so that he need not make any computations and assumptions.

J. A. HARVEY[12]:—That is very important to the operators, and I move that a committee be appointed to look into it and recommend to the manufacturers what information should be furnished in the specifications.

MR. WINCHESTER:—I second the motion. I understand that the action of this meeting can only be an advisory action.

CHAIRMAN W. A. GRUSE:—The motion is carried.

Many Variables Make Subject Complicated

C. M. BILLINGS[13]:—I should like to ask Mr. Wolf what percentage of the total cubic-inch displacement he uses for maximum-torque equivalent in pound-feet of the average truck-engine.

MR. WOLF:—I did not evaluate that. The figures were based on the maximum torque. Mr. Scaife objects to that, preferring to use less than the peak torque so as to cover a more complete range of vehicle action, and I think the point was well taken.

C. M. BILLINGS

MR. BILLINGS:—I have used a figure of 55 per cent of the displacement of the engine in cubic inches as representative of the maximum-torque value in pounds feet of the average truck engine. I have not checked some of the new high-compression engines and presume that a figure of 60 per cent would be nearer correct.

MR. WOLF:—A number of formulas have been based on such suppositions. The question is,

[10] M.S.A.E.—Sales engineer, Firestone Tire & Rubber Co., Akron, Ohio.

[11] M.S.A.E.—Superintendent of motor-vehicles, Standard Oil Co. of New Jersey, Newark, N. J.

[12] M.S.A.E.—Operating engineer, Pittsburgh Motorcoach Co., Pittsburgh.

[13] M.S.A.E.—Managing engineer, commercial car division, Vacuum Oil Co., New York City.

how many of these suppositions are we going to make? The information in the paper was presented in an effort to reduce the whole matter to a convenient method of comparison.

To eliminate a large number of these variables and make the subject more comprehensive, we must necessarily go through the entire range of speeds and road conditions in order to put it on a horsepower basis.

MR. BILLINGS:—That is true, but, as regards performance, the average operator is interested in knowing what grade his vehicle can climb with full load in any gear-ratio. If you take the torque curve of every individual engine, you can arrive at a very accurate figure, but, for the purpose of calculation, by finding a figure representing the maximum torque per cubic-inch displacement of a number of truck engines you can arrive at a figure that will be of value for checking and evaluating the performance as to pulling power and grade climbing of any given truck. The maximum speed of climb would, of course, be proportional to the engine speed at maximum torque.

A word relative to the efficiency of gearing. In 1914, when connected with the General Motors Truck Co., I conducted many experiments to determine the efficiency of gearing. We tested a great many bevel gears and, much to our surprise, found that the efficiency of the bevel-gear-drive ball-bearing axle never ran under 97 per cent, and, strange to say, varied very little with the adjustment of the pinion or gear. Those axles were speeded up to as high as 2000 r.p.m. and howled until we could not stay in the room, yet the efficiency was affected very little.

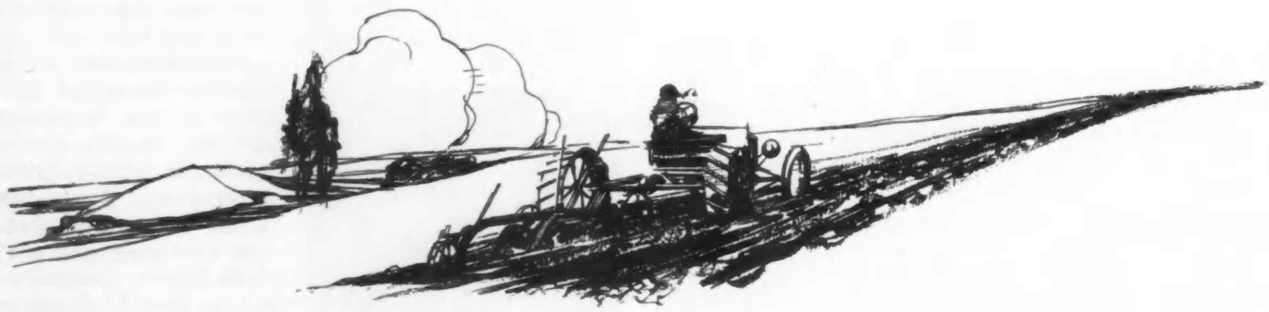
MR. HORINE:—Referring to Mr. Kemble's remarks, a man might want to know, not only how steep a grade he can climb, but at what speed he can climb that grade. Mr. Wolf's formula makes that perfectly possible if, instead of taking the peak torque, we take the torque at the particular engine-speed that will give the vehicle speed that is wanted. For example, if he wants to know how steep a grade the truck can climb at 15 m.p.h., he can find out how fast the engine will turn at 15 m.p.h., take the torque at that speed, and work the formula through. That will give the grade that can be climbed at that vehicle speed. There is nothing mysterious about the relation of torque to horsepower; horsepower is simply torque times speed.

Trucks Sold on Maximum Power

L. C. JOSEPHS, JR.[14]:—One point that perhaps has been lost sight of is that the object of getting these figures is to provide something that will help the salesman in the field by enabling him to determine a figure that is safe, based on tractive ability, allowing 5-per cent loss for gear efficiency and taking the different points on the torque curve. The engineer puts in all the factors of safety and comes out with good, safe figures, on the basis of which he will guarantee the truck to go up a given grade at a certain speed. The salesman's competitor comes along without any figures and says, "My truck will go up there twice as fast as that." The salesman usually has to sell the truck on every bit of its horsepower. No formula can be made to show that, because a formula has to be set up on average values and most salesmen sell maximum values. I think this is the thing we are all missing.

MR. SCAIFE:—I think that this paper is more of an engineering than an operation paper. However, engineering and operating are closely tied together. Mr. Horine brought out the point I have in mind; that is, that we are all talking horsepower and figuring torque. This is especially true of engines having large cubic-inch displacement wherein the maximum horsepower is developed at 2400 to 2600 r.p.m. and the engine is governed at a speed of 1800 to 2100 r.p.m. This is done to regulate the road speed and to secure the maximum economical life from the engine. It is then necessary to use the torque figure at a point on the curve between maximum torque and governed speed. This will give the speed at the ability required and the ability at the speed required.

[14] M.S.A.E.—Engineer, International Motor Co., Allentown, Pa.



The Future of Tungsten Carbide

Discussion of W. H. McCoy's Production Meeting Paper[1]

THE PAPER recounted the savings made in a number of instances by tungsten-carbide tools in various divisions of the General Motors Corp. and gave information to help in the selection of suitable jobs for the material and in designing adequate tools. The author predicted the development of different varieties of tungsten carbide for various purposes, variations being made in the grain size and nature of the binder.

Discussion of the paper began with a written contribution from an importer of the material, including a tabulation of recommended cutting-angles for tools to be used in different materials and describing four varieties of tungsten carbide produced by the one maker whom he represents.

Carbide was said to be practicable for intermittent cuts if tool shanks are made stiff enough and vibration and backlash in the support of the tool and the work are eliminated. A number of examples were cited in which great savings in production have been made because of the infrequent need of tool grinding.

Ordinary large-quantity production jobs and milling operations were said to offer the greatest chances for saving with the new tool material, and training of the operating personnel was said to be the greatest need for its successful use.

ROGER D. PROSSER[2]:—Mr. McCoy is to be congratulated for bringing out in a forceful manner some of the savings which can be made through the use of cemented-tungsten-carbide cutting-tools and for his interesting theories as to the possibilities of improving this material.

The definite figures showing speeds, depths of cut, and savings effected with cemented-tungsten-carbide tools are interesting and are by no means exaggerated. In fact, the cutting speeds could probably have been increased greatly in the majority of cases without exceeding the safe limits for the tool, provided that the machines would have permitted this increase in speed, with correspondingly greater savings. The surface speeds mentioned for machining cast iron appear to be very much below the maximum safe speeds for Widia cemented tungsten-carbide[3].

ROGER D. PROSSER

The feeds used in the various operations would be of the greatest interest, as the feed is a very important factor with tungsten-carbide tools. In general, the best results are obtained through the use of high speeds with the same feeds that are customarily employed with high-speed-steel tools, or even lighter feeds.

One additional instance of the durability of cemented tungsten-carbide that has recently come to light will doubtless be of interest. Fig. 1 shows the set-up for machining a bronze part. These tools were placed in the machine March 14 and at the present time, more than 6 months later, are still working perfectly, cutting cleanly, without having been reground or removed from the machine, which has been in continuous daily production during this period. The best high-speed-steel tools had to be reground several times every day on this operation.

Whether or not certain characteristics of cemented tunsten-carbide mentioned by Mr. McCoy should be classified as shortcomings is a question. Extreme hardness and great toughness do not go hand in hand, and one cannot yet expect to obtain the advantages of the great hardness and wear resistance of cemented tungsten-carbide and still retain the toughness of high-speed steel. In attempting to take advantage of the remarkable properties of this material it is therefore necessary to bear in mind its comparative brittleness, and to design tools and tool set-ups which will take care of this quality. Intermittent cuts can be taken with no difficulty when this is done, although it is necessary to avoid severe shocks where backlash is possible, as in stopping the machine with the tool in the cut and the feed on.

Size and Form of Tip Are Important

High heat-conductivity is one of the advantages of cemented tungsten-carbide, and the use of a tip large enough to conduct the heat rapidly away from the cut-

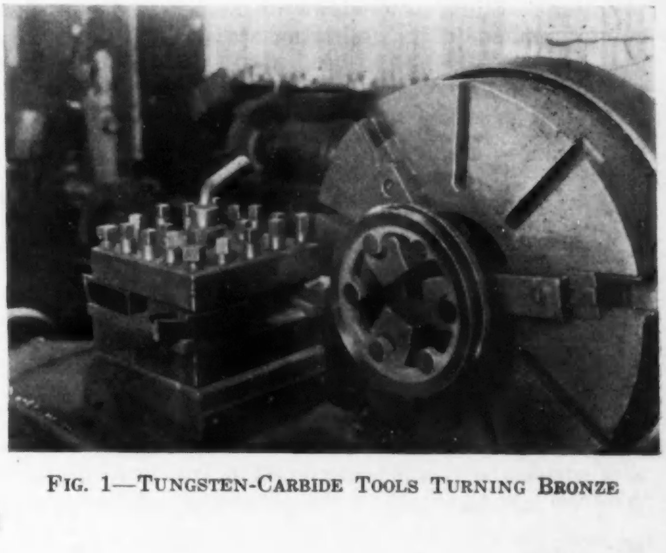


FIG. 1—TUNGSTEN-CARBIDE TOOLS TURNING BRONZE

[1] This paper was printed in the S.A.E. JOURNAL for November, p. 557. The author is manager of the research experimental production machine-shop, General Motors Corp., Detroit.

[2] Thomas Prosser & Son, New York City.

[3] See *Transactions of the American Society of Mechanical Engineers*, vol. 51, part 2, 1929, p. 71.

ting-edge is one of the first principles of successful application[4]. Many of the early failure were due to the application, by tool-makers inexperienced in the proper use of tungsten carbide, of thin tips which could not conduct the heat away rapidly enough.

The formation of a fin on the cutting-edge is to be avoided, not only because of the possibility of taking off a small portion of the tip if the fin breaks off, but also because of the increased chip pressure on the tool, which may eventually become so great as to cause breakage of the tip. This alloying or welding-on of a fin can be overcome to a large extent by the use of a larger tip, as stated by Mr. McCoy. A light cutting-oil is often of great assistance in eliminating this trouble, and the use of the proper tool angles for the material being machined is of the utmost importance.

In this connection, the principles stated in 1906 by Taylor in his famous treatise On the Art of Cutting Metals are still good, although with some modifications of angles for tungsten-carbide tools. A slight change in tool angle will often result in great reduction or elimination of this building-up of the cutting edge. It should also be noted that the clearance beneath the cutting edge should be kept as small as possible, usually about 4 deg., so as to give the maximum support to the cutting edge. It would be interesting to hear from Mr. McCoy what angles were used when this difficulty was encountered in machining soft steel.

Krupp's recommendations for Widia lathe tools, based on thousands of tests in the Krupp research laboratories and in actual practice are given in Table 1. The recommended tool angles have recently been modified slightly and those shown herewith represent the latest and best information. Planer tools should have the same angles, with a negative back-rake of 12-15 deg.

Various Grades Now Available

There is no question that several grades of cemented tungsten-carbide will be supplied for various applications, but I cannot believe that a large number of grades will ever be necessary, any more than a large number of grades of high-speed steel are necessary. The greater the number of grades, the greater is the stock of tools of this expensive material which will have to be carried, and the adoption of only one or two grades for general use should be of advantage to both the user and the supplier.

To meet the needs of general use and of special applications, Widia cemented tungsten-carbide is now being supplied in the following standard grades:

[4] See *Transactions of the American Society for Steel Treating*, vol. 17, June, 1930, p. 749.

TABLE 1—RECOMMENDED ANGLES FOR LATHE TOOLS

Material To Be Machined	Clearance Angle α, Deg.[a]	Tool Angle β, Deg.
Soft Steel	4	60–65
Hard Steel	4	65–74
12-Per Cent Manganese Steel	4	80–84
Stainless Steel	4	65–74
Chilled Cast-Iron	3	82–86
Soft Steel Castings	4	68–73
Hard Steel Castings	4	73–78
Grey Cast-Iron	4	74–80
Bronze and Brass Alloys	6	65–75
Aluminum Alloys	8	50–55

[a] A tolerance of plus or minus 1 deg. is allowed on the clearance angle.

(1) A grade combining a great degree of hardness with the maximum of toughness consistent with such hardness. This is supplied for general use in the machining of cast iron, non-ferrous metals and other materials.

(2) A grade having increased toughness with very little loss of hardness, especially useful for machining chilled cast-iron rolls. It is also useful for certain other applications where a somewhat tougher grade is needed.

(3) A grade of exceptional hardness for use where resistance to abrasion is essential but where only light cuts are taken, as in finishing cast-iron piston-rings and machining abrasive non-ferrous materials.

(4) A special grade for rock drilling.

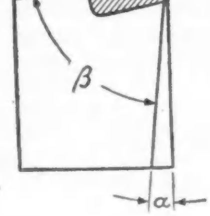
W. E. SMITH

Hardness Is Principal Virtue

It is true that the low transverse strength of cemented tungsten-carbide has been the cause of some dissatisfaction with the material, but in the majority of cases any difficulties that have been encountered can be overcome by redesigning the tools and set-ups to take this limitation into account, disregarding practice with high-speed-steel tools. Thus it is possible to obtain the advantage of extreme hardness, wear resistance and enormous compressive strength, rather than to sacrifice hardness and efficiency for a slight gain in toughness. Some tungsten carbides that have been placed on the market possess increased toughness but hardness and wear resistance only slightly greater than the usual cobalt-chromium tools.

Mr. McCoy's theories as to how improvements in cemented tungsten-carbide will come about are extremely interesting, and it is to be hoped that an increase in toughness will be possible without great sacrifice in hardness; but it is very important to avoid a sacrifice of the principal advantages of cemented tungsten-carbide, which are extreme hardness and wear resistance.

Again it should be emphasized that cemented tungsten-carbide is not a cure-all for machining troubles. Many times its best applications and the places where the most money can be saved through its use are on jobs which are giving very little or no trouble. Tough jobs can often be made easy with the material, but the biggest savings will be found to be on everyday high-production jobs where increasing the cutting speed or tool life between grinds is the important factor.



W. H. McCOY:—Answering Mr. Prosser's remarks about feeds and speeds; we do not recommend trying to use a speed of 1500 ft. per min. on gray iron when probably the tool will pay for itself at 300 ft. per min. On some machines we are using a

speed of 600 ft. per min. on this material, and these machines are removing a lot of material. We usually leave the feed about as it was with the high-speed-steel tool and try to double or triple the speed. In this way, we have had very few tools rejected because they did not do the work. We also find it necessary to overcome prejudice in regard to clearance angles on tools in some cases to prevent failures.

Large Shanks Needed for Intermittent Cuts

A MEMBER:—The impression has been created that tungsten carbide is not good for intermittent cuts. Is not that due to using tools having insufficiently large shanks?

MR. McCOY:—That seems to be true. One of the General Motors divisions is now using tungsten carbide for intermittent cuts. As long as we can keep a tool steady, by providing heavy shanks and tips and preventing backlash in the cross feed, the interimttent nature of the cut has little effect.

A MEMBER:—William Sellers & Co., Inc., Philadelphia, has had excellent results with tungsten-carbide tools for intermittent cuts, using tools having exceptionally heavy shanks, and I think extremely heavy shanks are being used in the majority of cases where intermittent cuts are being made successfully. Is it not a fact that Krupp's has turned square billets of steel?

MR. McCOY:—Yes, they are doing that.

A MEMBER:—One question that has puzzled me is why we are not getting results in turning steel in this Country such as they are getting in Germany.

W. E. SMITH[5]:—Tooling for intermittent cuts with tungsten-carbide tools is complicated by the fact that these tools require a greater shank size than is necessary with a high-speed-steel tool to withstand the shocks of intermittent cutting. Most American machine-tools are designed so that it is impossible to increase the size of the tool shank.

W. H. McCOY

Dr. S. L. Hoyt and I spent considerable time in the development of tungsten-carbide tools in the research laboratories of the General Electric Co., and our experience has shown that intermittent cuts can be made under suitable conditions, provided that the tool shanks and tips are heavy enough. With intermittent cuts it is necessary to consider both the strength of the tool and the material which is being machined. We tried planing armor plate, which had never been attempted before, using tools approximately $2\frac{1}{2}$ in. square. We found that these shanks were too weak to withstand the shock and had to use a considerably larger shank to eliminate tool failures due to the impact and shock of intermittent cutting.

A MEMBER:—Is it not true that the majority of failures of tungsten-carbide tools are due to poor design with reference to the strength of the tool?

W. E. SMITH:—That is undoubtedly true, but any six machinists or mechanical men are likely to have six different opinions as to what constitutes a good tool. The master mechanic of a large machine-shop will say that a certain tool is correct for the job, and the man at the lathe will say that the same tool is not right. The human equation must be considered in all designing of tools. These tools may be used by men who were pitching hay the day before.

Increased Experience Breeds Confidence

W. H. GRAVES[6]:—I should like to ask Mr. McCoy whether he would specify tungsten-carbide tools for a new operation or would begin with steel cutting-tools. If he would specify tungsten-carbide at all at the start, on what types of job?

MR. McCOY:—We will specify tungsten-carbide tools at the first on new machines for some jobs, particularly in gray iron or aluminum where fine feeds and smooth finish are required. If production is demanded in a hurry and there are intermittent cuts or other unfavorable conditions, we should prefer to use high-speed steel first. When the tungsten-carbide tool is applied, it may be necessary to make some changes in the clearance angle or rake angle before the tool is finally successful; after that, it will certainly pay for itself.

Two years ago the manufacturers of this material knew no more about making or tipping tools than we did. In the meantime, they have spent so much money in trying different tools in service that their business has not yet begun to show a profit, as their practice has been to install tools and experiment with them at their own expense until the tools did the work satisfactorily.

E. R. SMITH[7]:—What changes are needed in designing machine-tools to make them available for use with tungsten-carbide cutting-tools?

MR. McCOY:—Rigidity is the prime requirement. Lost motion in the cross slide must be prevented, and the bearings must be large enough and long enough to support the work rigidly. The horsepower must be sufficient to carry the cut without stalling. Adjustable roller-bearings and high speed-capacities that make decreased feeds practicable will help in the application of tungsten-carbide tools.

E. R. SMITH:—Have hydraulic feeds been found better than screw or cam feeds?

MR. McCOY:—I know of no instance in which hydraulic feeds have been used in this connection.

E. R. SMITH:—Have you found any difference in effect between plain bearings, roller-bearings and ball-bearings?

MR. McCOY:—No. Any bearing that is fitted closely enough to prevent chatter works very well.

Building-Up on Cutting Edge

R. L. TEMPLIN[8]:—When the ideas that are being advocated here for the use of tungsten-carbide tools are accepted, the greatest problem in machining aluminum will be solved.

Our experience checks Mr. Prosser's statement that the building up of metal on the cutting edge of the tool can be overcome by the use of correct tool-angles. Sufficient top and side rake almost entirely eliminate this difficulty. The front clearance angles given by Mr.

[5] Manager of Widia department, Wesson Sales Co., Detroit.
[6] M.S.A.E.—Chief metallurgist, Packard Motor Car Co., Detroit.
[7] A.S.A.E.—Vice-president, general manager, Seneca Falls Machine Co., Seneca Falls, N. Y.
[8] Chief engineer of tests, Aluminum Co. of America, New Kensington, Pa.

Prosser for tools for aluminum check very well with our own experience. This angle usually is a function of the modulus of elasticity of the material being cut; the lower the modulus, the greater the clearance angle needed.

A serious problem in connection with intermittent cuts is the circular saw having tungsten-carbide tips. We believe that these can be used very satisfactorily in aluminum and its alloys if the work is clamped rigidly, if the saw table has positive feed without lost motion, if the saw arbor is rigid and if critical vibration can be avoided in the saw itself. For tipping such tools, we advocate a tip of trapezoidal or keystone shape, with the large end toward the shank of the tool to distribute the bearing stresses.

A MEMBER:—Could not a great part of the trouble with tungsten-carbide tools be eliminated if the emery-wheel stands accessible to the operators were abolished? I frequently notice in shops that tools are in improper shape because of the fact that each man is allowed to grind his own. The only way to solve the problem is by establishing a tool-grinding department.

MR. MCCOY:—That is true. In the General Motors divisions we have men who do nothing but take care of the tools. If an operator has a tool that needs grinding, he turns it in and gets from the crib another tool that has been correctly ground. That condition has helped much in applying tungsten-carbide tools.

W. E. SMITH:—My observation in regard to metal building up on the edge of a cutting tool is that quite a few of the industrial metals have a great tendency to gall under pressure. Considerable pressure is built up in cutting metals, and the metal adheres to the cutting edge mostly by molecular attraction, without actually fusing to the tool. For instance, in cutting manganese steel, which has a great tendency to gall, the cutting edge of the tool is gradually covered by what might be termed a small cap or covering of such manganese steel. Because of this gradually increasing deposit, the cutting is not actually done with the keen, sharp edge of the tool, but with this manganese-steel-covered cutting-edge. The result is that crowding sets in, which results in ever-increasing pressure. This crowding effect can be observed by installing a recording meter in the power circuit of the machine. The horsepower curve shows a gradual increase as the pressure rises because of the crowding. When this crowding effect reaches a certain point, the pressure exceeds the strength of the tool tip and the tip breaks off.

MR. MCCOY:—Our experience in machining aluminum has been very satisfactory. The building-up of which I spoke was in machining soft steel. We use large rake angles with aluminum and lap the tools very smooth, giving the chip a chance to get away without building up on the tungsten-carbide tip. We are trying to overcome the abrasion of the alloy in machining soft steel by providing heavier tips to dissipate the heat, and we are meeting with success along that line.

MR. TEMPLIN:—Has Mr. McCoy ever tried on annealed steel any of the tools of the sort ordinarily used for aluminum? I found that our men have used such tools in turning annealed high-carbon steel, after they were trained to use such tools for aluminum, with very satisfactory results. The only difficulty they find is that the long chips resulting are hard to dispose of; they are able to remove the metal at a very high rate.

MR. MCCOY:—I have not tried tools of that sort for steel. We have a department that is specializing in the designing and fabricating of tungsten-carbide tools. We became interested in the material because of the savings that we made about two years ago, especially on die-cast white bearing-material and malleable-iron differential-cases.

Longer Tool Life and Faster Production

JOHN YOUNGER[9]:—What is the source of economy in the use of tungsten carbide; is it from greater life of the tool, greater production or a combination of both?

MR. MCCOY:—A mixture of both. A tool lasts longer than a corresponding high-speed steel or Stellite tool, and it saves down time of the machine.

W. G. ROBBINS[10]:—An impression may have been created that tungsten-carbide tools should be used with very high speed and other special conditions. It is true that such conditions should be provided in order to obtain the maximum benefit from the tool. However, it is not possible to do this in all cases, because manufacturers cannot afford to scrap the machines that they are using. It is perfectly possible to prove in the use of tungsten carbide without increasing the cutting speed. I know of one prominent manufacturer who is doing that at the present time, the advantages being longer life of the tools and less down time of the machines. All in all, they have found a material saving compared with other cutting-tools.


W. G. ROBBINS

W. E. SMITH:—Mr. McCoy has been very conservative in regard to cutting speeds, and I believe that he is correct in being so. I have seen jobs on which speeds as high as 1500 ft. per min. could be attained, with corresponding short tool life, whereas tools run two to three weeks on the same job at what might be called an economical speed of 350 ft. per min.

High speeds are not always necessary for tungsten-carbide-tipped tools to show an advantage. Mr. Robbins has reported a certain job on which the surface speed could not be increased because it was a double set-up. Nevertheless, tungsten-carbide-tipped tools reduced the time used up for tool changes from 1 hr. for each 8-hr. shift to approximately 1½ hr. in 3 weeks. Another case involved Stellite tools which had to be ground after cutting 20,000 pieces of Bakelite. The regrinding and resetting of the tools took approximately 1½ to 1¾ hr. The speed of this particular machine could not be increased, but applying tungsten-carbide tools increased the production to 225,000 pieces for each grinding.

In another case, we were laughed at for trying to sell a tool material as expensive as tungsten carbide for a job on which old files were being used for tools. Nevertheless, the tools made from old files had to be ground after approximately each 15 pieces, and the regrinding required 15 to 35 min., according to the shape desired. A set of tungsten-carbide tools was installed on this

[9] M.S.A.E.—Editor, *Automotive Abstracts;* professor of industrial engineering, Ohio State University, Columbus.
[10] Vice-president, Carboloy Co., New York City.

job, with the result that regrinding was required only after approximately 250,000 pieces, the cutting being done at the same speed.

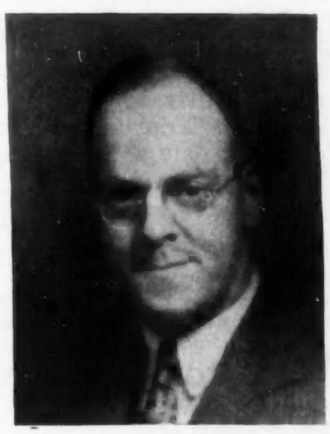
Tungsten-carbide tools sometimes have proved themselves invaluable in saving castings that could not be machined otherwise. In one case, between 15 and 20 large, solid high-speed-steel tools were broken in attempting to machine a hard casting that was worth approximately $15,000. Two tungsten-carbide-tipped tools costing about $100 completely finished this job, although they were somewhat chipped during the turning operation.

Referring to the question of bearings for machine tools, ball and roller-bearings certainly do make possible higher speeds than those obtainable with plain or straight bearings. In several tests, the plain bearing of some of the lathes seized when we attempted high speeds for any length of time. This has very rarely happened with roller or ball-bearing-equipped machines.

Carbide Adds to Speed of Milling-Cutters

MR. ROBBINS:—Milling-cutters tipped with tungsten carbide seem to furnish the greatest opportunity for savings of any type of tungsten-carbide tool. Ordinary milling-cutters can remove metal very rapidly; but much higher speed is possible with tungsten carbide, and the tool life is greatly increased besides. As in lathe-tools, it is important that the cutter tip be provided with sufficient backing, and that may mean fewer and thicker blades in the cutter. The outstanding advantage is the great length of service between grinds.

One example of milling-machine service is on a machine for milling cylinder-blocks. The cutters are run at the same speed as the high-speed-steel cutters formerly did, and they have been in service for 3½ months without being removed for grinding. Milling-cutters on another job on cast iron required grinding after 4 hr. of work. The carbide-tipped cutter works about 80 hr. on one grind. Another advantage is that hard spots, which ordinary cutters would fail to remove, are cut through by the carbide cutters. This reduces scrap and avoids remilling operations.



V. E. WALTERS

C. J. OESTERLEIN[11]:—What experience has been had in milling alloy steels?

MR. ROBBINS:—We have not attempted to make tungsten-carbide milling-cutters for steel.

A. H. LYON[12]:—How much more power is required to remove metal with a tungsten-carbide tool than with a high-speed-steel tool?

MR. MCCOY:—I have no definite information available, but I know of one case in which a motor was increased from 7½ to 30 hp., using higher speed.

W. E. SMITH:—Tests conducted covering the researches of Professor Schlesinger and Dr. Kronenberg, of Berlin, Germany, and confirmed by them in papers and publications, also substantiated by tests conducted by the United States Bureau of Standards show that the horsepower demand does not increase in any such ratio as from 7½ to 30. The torque required can be computed from the area of the chip and other data. Increasing the speed does not increase the power demand in the same ratio as the speed is increased. I firmly believe that there is a distinct relation between the size of chip—that is, the product obtained by multiplying the depth of cut by the feed—and the size of the tool shank required, at the same time taking into consideration the material that is being cut. In cutting certain very hard materials I found that we are safe if the chip area is not greater than 2 per cent of the cross-sectional area of the tool shank, but that tool failure results when the chip is increased beyond that percentage. I cannot state exactly how much the percentage must be increased to result in tool failure, but I am conducting experiments along this line.

J. GESCHELIN[13]:—Are the grinders now in use in tool-rooms adequate for grinding tungsten carbide?

MR. MCCOY:—The grinders themselves are satisfactory, but special wheels are required. Wheels for the purpose are being improved constantly. Wheels are now available that finish the tools almost like a lapped surface. Surface grinders also are being used instead of hand grinders.

MR. GESCHELIN:—Is it necessary to lap the tools after grinding in every case?

MR. MCCOY:—We lap all these tools, because we wish to give them the best possible chance in each application. Sometimes the lapping is done with diamond dust and sometimes with a less expensive abrasive that works very well. Most of our divisions now have lapping-machines for the purpose.

MR. GESCHELIN:—I have heard it said that lapping is not absolutely essential, excepting for certain jobs on aluminum.

Operators Blamed for Failures

V. E. WALTERS[14]:—Education of the operators is the greatest problem in connection with cemented tungsten-carbide. It has been tried for a number of jobs at the Oakland plant and has succeeded in only one case. I do not attribute the failures to the material itself but rather to our failure to train the operators properly.

The jobs on which we have tried the material might be of interest to you. One of the first was finishing pistons on an 8-in. Sundstrand lathe. The trouble in this case was due to the operators; we know of instances in which the operator deliberately broke the material. We also find that the tools cannot be set in the same way as high-speed-steel tools are set. Operators will adjust the tools by partially loosening the clamp screw and tapping the tool. Such treatment causes the tungsten carbide to chip off.

We have tried tungsten carbide as a substitute for diamonds in boring connecting-rods on a two-spindle Coulter machine and were unable to obtain a finish that was satisfactory to the inspector. We have also tried it on axle-drive gears and other forgings, and the tools did not stand up.

About a year ago we received a lot of malleable-iron differential-case castings that were hard. As no other

[11] Vice-president, Oesterlein Machine Co., Cincinnati.

[12] M.S.A.E.—Chief engineer, Ingersoll Milling Machine Co., Rockford, Ill.

[13] M.S.A.E.—Associate engineering editor, *Automotive Industries*, Philadelphia.

[14] General master mechanic, Oakland Motor Car Co., Pontiac, Mich.

castings were available, the operators had to choose between machining that material with tungsten carbide and shutting down the axle plant. We spent a great deal of time with the operators on that job and succeeded with it. After the hard castings were machined, the operators would not part with the tungsten-carbide tools. The operations are roughing and finishing the hubs and gear flanges of a one-piece differential-case. The cutting speed is 140 to 150 ft. per min., and we are machining about 4000 pieces per grind. These are the only operations upon which we have been successful so far with tungsten-carbide tools.

As Mr. McCoy has said, it is necessary to assign a man to the problem of applying tungsten-carbide tools and to give him help enough to actually operate the machines and to demonstrate to the operators and superintendents what the material will do. There is no doubt in my mind that it has wonderful possibilities.

We do not allow the operators to grind the tools that are used on the differential case; they are ground on a surface grinder and set at the proper angles by means of blocks. The tools are removed and sharpened as soon as they begin to show dullness at the edge, so the average metal removed in grinding is only 0.005 to 0.008 in. The marks of the grinding-wheel are then smoothed off with an abrasive stone. The wheels best adapted of any that we have found for the job are Carborundum or Staralon 80 R.

Possibilities of Low-Grade Fuels Overestimated

(*Concluded from p.* 95)

some places, from 50 to 60 cents per gallon. What can the oil companies do for us in those countries?

MR. WILSON:—There you may have a margin really worth working on. In the first place, the foreign market insists on very low-boiling gasoline and seems to be too stubborn to change; in the second place, most countries have very high import duties on gasoline, which will probably spread to other fuels as time goes on and they begin to be used more generally in internal-combustion engines. There is, however, a larger margin to work on in the export field. Under those conditions the building of an engine to use low-grade fuels might be justified, but the fact remains that close boiling-point specifications on heavier fuels must make the fuel cost more.

In other words, if furnace oil can be any light distillate which cannot be used for gasoline, that is one thing; but if it has to be refined, tested and blended, those processes add to the cost and decrease the available supply. It is very difficult in those countries to know what is meant when a low-grade fuel is demanded, such fuels being tremendously variable in knocking and gum-forming tendency and so on.

FRED M. YOUNG[5]:—Do you feel that the urge of the manufacturers to build Diesel engines for aeronautic purposes is on account of danger from fire? There is a marked saving in fuel, but the fire hazard seems to be one of the principal factors.

MR. WILSON:—The fire hazard is an additional argument in the case of airplanes, though I believe that there are other methods of preventing fires which have proved fairly successful. Certainly we do not have nearly so large a percentage of airplane fires as we once did, but a Diesel engine is an added factor of safety in that respect.

[5] M.S.A.E.—President and general manager, Young Radiator Co., Racine, Wis.

Scientific Inspection Reduces Motorcoach Operating Costs

(*Concluded from p.* 88)

operated per mechanical failure in the standard classifications covering an operation in which all of the motorcoaches assigned to this particular garage are in long-distance high-speed service, which is the hardest service of the entire system. The high mileage per failure is to a large extent due to the efficiency of the door inspection.

Maintenance Research by Manufacturer Urged

Something seems to be retarding the scientific development of maintenance, and I believe that the manufacturers who have concentrated their research facilities almost entirely upon the production of vehicles can divert some part of their facilities to the solution of maintenance problems, thereby reducing the operating cost of commercial vehicles, which in many cases would make possible the purchase of more vehicles.

Let me suggest that, as a movement in the right direction, the manufacturers of commercial vehicles remove the ban against the furnishing of blueprints and working drawings to maintenance men and establish a department to study scientific maintenance in collaboration with the operators so as to establish standard practices for the repair shops. Surely such a policy will be profitable to the manufacturers in providing accurate information for future design, and will also bring about a very close relationship between the manufacturer and the operator, to their mutual benefit.

Automotive Research

Progress in Vapor-Lock Study

Summer Investigation of Fuel-System Temperatures To Be Reported at Annual Meeting

"THE antiknock value or detonating tendency of a fuel is regarded popularly as the one major and outstanding property of motor gasoline. This emphasis of the antiknock value may at times be responsible for the under-emphasis of other properties of motor fuels that exert an equal and possibly even greater influence upon engine performance," declared H. T. Ramsay, of the Standard Oil Co. of California, in a paper presented at the February, 1930, meeting of the Southern California Section of the Society. He remarked that the one other fuel characteristic that is given serious consideration by the petroleum manufacturer, but possibly little thought by the layman, is volatility, the characteristic which controls "gas lock."

The engineers who represent the American Petroleum Institute, the Society, and the National Automobile Chamber of Commerce on the Cooperative Fuel-Research Steering Committee are not guilty of this oversight regarding the importance of motor-fuel volatility and its influence on vapor lock.

Investigation Sponsored by the Society

More than two years ago an investigation on this subject was undertaken at the Bureau of Standards under the sponsorship of the Society with funds provided by the Naturaline Co. of America. The first phase of the research concerned vapor lock in aircraft engines, where the importance of understanding this phenomenon has been dramatically demonstrated by engine failures. Realizing that the trouble is none the less prevalent, though not as hazardous, in automobile operation, the Cooperative Fuel-Research Steering Committee undertook the extension of the investigation to automobile fuels and automobile engines.

The problem was attacked from two angles: the effect of fuel characteristics and the effect of engine design. A series of reports presented at the Society's meetings and published in the S.A.E. JOURNAL[1] have shown that the temperature at which a given fuel will vapor-lock can be predicted from the A.S.T.M. distillation curve corrected for loss. Thus the research has established that no complicated tests, in fact, no tests at all other than those which are customarily run on the gasoline, are necessary to predict vapor-lock behavior.

Factors Affecting Vapor-Locking Tendency

The effect of volatility, temperature and other factors upon the vapor-locking tendency of fuels is set forth as follows by Graham Edgar, J. B. Hill and T. A. Boyd in a paper entitled, The Meaning of the Gasoline Distillation Curve, presented at the 11th annual meeting of the American Petroleum Institute on Nov. 12, 1930:

Vapor lock will occur when the fuel boils in any part of the fuel-feed system up to and including the carbureter passages. This will occur when the temperature at any of these points becomes so high that the vapor pressure of the fuel exceeds that of the atmosphere. It has been shown that the temperature at which gasoline free from propane will boil is equal to the A.S.T.M. temperature for 10 per cent evaporated. If the gasoline contains an appreciable quantity of propane, it will have an abnormally high vapor pressure and will, therefore, boil at a temperature lower than that of the 10-per cent point. For such gasolines, the vapor pressure itself is a more accurate measure of the tendency to vapor-lock than the 10-per cent point. For most gasolines, which are essentially free from propane, the 10-per cent point and the temperature which the gasoline may reach in the fuel system are the main factors determining the tendency to vapor-lock.

Now, the temperature which the fuel reaches in the fuel system is determined by (*a*) atmospheric temperature; (*b*) the conditions of operation, as speed, load, etc.; (*c*) the location and design of the fuel lines and carbureter, and by such equipment factors as thermostats, radiator shutters, and the like.

Furthermore, the problem is complicated by several other factors. In the first place, the properties of the fuel in the fuel system may not always be identical with those of the fuel as supplied to the tank. A certain amount of evaporation of lighter ends (stripping) may occur in the fuel tank, in the vacuum tank, and in the carbureter bowl itself, so that it is possible for the fuel to be heated somewhat above the temperature at which 10 per cent of the original fuel evaporates without vapor lock occurring. Again, the presence of sharp bends in the fuel lines or abrupt changes in their diameter increases the tendency to vapor-lock with a given fuel under given conditions.

Marked differences are then to be expected, and are found in practice in the vapor-locking tendencies of a given fuel in different automobiles. A fuel which will operate with entire freedom from vapor lock in one automobile may give much trouble in another. It is, therefore, impossible to specify definitely the minimum 10-per cent temperature, or maximum vapor pressure, which a fuel should possess, without reference to the characteristics of actual automobile fuel systems.

Temperature Measurements under Operating Conditions

Feeling that the designer of automotive equipment could do much to minimize trouble from vapor lock by reducing fuel-line temperatures, the Steering Committee undertook a program of temperature measurements in automobile fuel systems under operating conditions during the last summer season. The investigation was conducted on a cooperative plan. The General Motors Corp. contributed to the Committee and the Bureau of Standards certain data which it had obtained previously, and a number of car manufacturers made available 27 cars for use in the test work. In addition, a New Jersey motorcoach operator loaned eight coaches for this purpose. These tests have indicated a number of simple changes in engine design which the engine builder can make to secure the best possible performance with the fuels available.

Dr. O. C. Bridgeman, of the Bureau of Standards, gives the following outline of most recent findings in this work:

Fuel-line-temperature data were obtained on 27 cars and 8 buses at several points between the main tank and the carbureter under a variety of operating conditions covering constant-speed runs from 20 to 60 m.p.h., followed by idling periods and hill-climbing runs. For comparability, all data were expressed as increases above atmospheric temperature. On the average with automobiles, the temperature of the fuel at the carbureter was 41 deg. fahr. above that of the atmosphere. Of this average rise in temperature, 18 deg. fahr. was found to occur in the rear tank, 11 deg. up to the engine compartment, 12 deg. in either the pump or the vacuum tank, and no change on the average from the pump or vacuum tank to the carbureter. Also, there was a still further increase of 14 to 19 deg. fahr. during idling after a 40-m.p.h. run, making the total increase about 60 deg. fahr. above the atmospheric temperature.

Interpreting these average temperature data in terms of gasoline vapor pressures and vapor lock, the rise means that a gasoline must have a Reid vapor pressure less than 8 lb. per sq. in. if vapor lock is to be avoided when driving at 40 m.p.h. with an atmospheric temperature of 90 deg. fahr. If

(*Concluded on p.* 118)

[1] See S.A.E. JOURNAL, July, 1930, p. 93; August, 1930, p. 218; September, 1930, p. 344; and October, 1930, p. 444.

Depreciation Problem Studied

A. J. Scaife[1] Analyzes This Cost-Finding Item at Baltimore Section Meeting

THE depreciation problem confronts every owner of motor-vehicle equipment. Sooner or later he must determine how he can best charge-off the investment he made in that equipment. Frequently, he uses comparative depreciation costs to determine the particular make to purchase and, in any event, he wants complete information on operating costs.

If the fleet owner attempts to reach the solution from the experience of other truck owners, he immediately finds a wide difference of opinion, not only as to the proper period over which to spread the charge, but as to the best method of applying the charge. In a recent article summarizing the practices of nine large-scale motor-coach-operators, it was shown that five favored a mileage basis varying from 150,000 to 300,000 miles, while the other four favored the annual percentage method over three to ten-year periods. The problem is not simple, but there are very definite principles upon which the right approach can be made.

What is Depreciation?

Depreciation is merely a bookkeeping device used to restore the purchase price to the account from which it was taken, and to approximate the economic life of a truck, so that depreciation costs can be applied to those periods of time in which they accrue. The term "economic life" is that period, usually expressed for convenience in terms of time, during which the truck can be operated with economy as compared with buying and operating a new truck.

The reason a truck has to be replaced eventually at the end of its economic life is that it will either wear out through use or become obsolete through age. Economic life, therefore, relates to both mileage, causing wear; and to time, causing obsolescence. Two conclusions logically follow: (*a*) that any method of depreciation used to approximate economic life must take into consideration both factors of time and mileage; and (*b*) that an accurate determination of the true economic life must be made before any method of depreciation can be applied properly. Further, the sound understanding of these two conclusions is prerequisite to the selection of the proper method to use.

[1] M.S.A.E.—Consulting field engineer, The White Motor Co., Cleveland.

Is Depreciation an Operating Cost?

Our definition of depreciation indicates that the sum set aside by this device is a reserve and, at the same time, an operating cost. Depreciation provides the replacement price. It also takes out of gross income the cost of that provision. The actual using up of truck equipment is a very definite expense of operation that must be borne by the operation which caused it. A trucking concern which forgot to include this item in setting up rates for hauling would soon find its capital expended and no reserve provided to restore that capital. For these reasons, it is extremely important to include depreciation charges in operating costs.

There may be a question as to whether it is not possible to repair truck equipment year after year, so that the truck need never be scrapped except for obsolescence. Even if this be true, there is nothing gained. A certain quality, a certain service, a certain number of miles, a certain resistance against stress and strain, wear and tear, and a certain life, are built into every truck. Sometime that quality, that service, that life, will be used up and the truck will be considered as worn out.

If the owner elects to pay excessive repairs and overhaul the job completely at that point, and then repeat the process again and again instead of buying a new truck, he has simply replaced the truck piecemeal at an excessive cost in parts, units and labor. The more common practice is to replace the entire truck; but whether the original capital is restored at once or gradually over a long period, there is the same need for a reserve fund. Likewise, depreciation under either method is a vital part of operating costs.

The Method of Depreciation

In the main, three principal methods of depreciation of motor-vehicle equipment are recognized and used most frequently:

(1) *The Fixed Annual Percentage Method.*—To charge off each year a fixed percentage, such as 10, 20, 30, etc., per cent of the original delivered cost of the equipment

(2) *The Mileage Method.*—To charge off a fixed rate per mile operated, determined by dividing the probable life expressed in mileage into the original delivered cost

(3) *The Fixed Percentage of Remaining Value Method.* — To charge off each year a fixed percentage of the value left from the preceding year.

Method (3) is a refinement of the first plan, and in many respects a very sound refinement. However, we need consider only the first two major methods; that is, fixed percentage per year and fixed rate per mile.

Owners who advocate the fixed percentage per year point out frequently that motor equipment is still in the stage of rapid development and that this method affords the better protection against obsolescence. If the average daily mileage operated is small, that much greater danger of obsolescence exists. Consequently, we find an overwhelming majority of operators who have low mileages making use of the fixed-percentage plan. It is also claimed that this basis is more easily understood and considerably more simple and convenient. The accountant, to whom the average owner delegates this task, writes off buildings and other equipment at a fixed annual rate. He prefers to follow the same plan for truck equipment.

To the foregoing plan there would be little objection if the accountant did not go one step further, but he also prefers to use the same arbitrary fixed percentage on all makes, regardless of quality, and on all units of the same make, regardless of operation. The result is a method which absolutely fails to coincide with the true economic life of the truck and which is obviously unsound for cost-keeping purposes.

It is partly to overcome this objection that an equally large number of owners advocate that depreciation be charged by the mile. Granting that the mileage method may require greater effort to apply and is admittedly less convenient, it is a well-known fact that the variables in average mileage and operating conditions which affect depreciation can be expressed better and be more accurately determined on the mileage basis. As an additional advantage, some operators point out that the mileage method allows a lighter charge for depreciation during dull periods when the job is not running many miles, and a proportionately high charge during the active periods when the truck is bringing in large returns. For these reasons, the mileage basis is more frequently recommended by students of the depreciation problem. Our own belief is that either method can be used

TABLE 1—SHOWING NECESSITY FOR DEPRECIATION ADJUSTMENT

Make of Truck	*A*	*B*	*C*	*D*	*E*
Purchase Price	$2,550	$2,550	$2,100	$1,850	$1,200
Age When Traded In, years	8½	6	4½	4	2½
Annual Depreciation; Based on 4-Year Life—25 per cent per year	$637.50	$637.50	$525.00	$462.50	$300.00
Annual Depreciation; Based on Actual Life	$300.00	$425.00	$466.67	$462.50	$480.00
Supposed Annual Savings as Against Truck *A*	......	......	$112.50	$175.00	$337.50
Actual Annual Loss as Against Truck *A*	......	$125.00	$166.67	$162.50	$180.00

satisfactorily, provided that first the true economic life of the truck is estimated carefully in terms of both wear and obsolescence or both mileage and time.

Practical Example Cited

To illustrate, let us assume that Truck *A*, costing $2,000, under a given set of conditions can be expected to operate safely 100,000 miles at average mileage per day. One might not recommend that high a mileage life, if it were to take 20 years to get the 100,000 miles, because of the obsolescence factor. Yet 100,000 miles might be used safely if that total were reached in five years of operation. In brief, this particular truck is good for a life of 100,000 miles during five years. If the expected mileage, based upon past experience, averages 20,000 miles per year, it makes very little difference whether depreciation is written off at 2 cents per mile or at 20 per cent per year. The important thing is that we use a "mileage-during-time" or "time-for-mileage" interpretation of what economic life this truck would have.

Determination of True Economic Life

The danger of unsound depreciation lies not so much in the method used as in the failure to base that method on the proper economic life found in trucks of variable quality operating under variable conditions. If longer life for the quality truck or the low-mileage truck, and shorter life for the low-grade truck or the truck operating under severe conditions, is once recognized and expressed in the method of depreciation, there is little objection to be found in either the fixed-percentage or the mileage-rate methods.

If our conclusions up to this point are sound, it is apparent that the owner must study his own situation. If he finds that the convenience of the yearly percentage plan outweighs his need for more accurate mileage-costs, he has merely to estimate first the probable life of the particular truck in his type of service and set the right percentage to write off his equipment in that period of years. If, on the other hand, he realizes that mileage costs are desirable and that the mileage method of handling depreciation costs controls his problem better, he must still determine the true economic life, expressed this time in terms of miles, and set his mileage rate accordingly. In either event, the rate of depreciation cannot be arbitrarily arrived at; rather, it must be adjusted to quality of equipment, average mileage and operating conditions.

A most interesting illustration of this point is shown in Table 1. This owner operated several makes of truck, shown as *A*, *B*, *C*, *D* and *E*. Irrespective of make or mileage, he depreciated his equipment at the rate of 25 per cent per year. On this gasis, Truck *A*, purchased at a higher list-price, was costing $139.50 more per year for depreciation than Truck *E*; but, when these trucks were traded in for new equipment, the owner quickly discovered his mistake. The higher-quality truck, *A*, operated for an average of 8½ years before being traded in. The actual depreciation cost was therefore reduced to $300 per year or about 12 per cent. Truck *E* had to be traded in at the end of 2½ years for the same trade-in allowance. This resulted in a yearly depreciation of $797, or 40 per cent. Whereas the owner had assumed that Truck *E* was saving $139.50 per year over Truck *A* in depreciation cost, it was actually costing him $497 more per year than Truck *A*. This owner had not determined the true economic life of the two trucks. His mistake was not the fault of the method used, but the fault of trying to apply an arbitrary rate to all makes and all conditions.

Almost the same error occurs when these trucks are depreciated on an arbitrary basis of 100,000 miles, without regard for quality, as shown in Table 2. Truck *A* made 110,000 miles before it was traded in, whereas Truck *C* made only 50,000 miles. If both trucks had run exactly 100,000 miles, the owner would have saved $0.0135 per mile in depreciation cost on Truck *E* as against Truck *A*, because of the lower purchase-price. Instead, the actual depreciation cost per mile on Truck *E* is $0.0068 per mile larger than the cost per mile for Truck *A*. Here again the fault lies in failure to recognize the longer economic life, whether expressed in years or miles, that is found in the high-quality equipment. The arbitrary rate simply will not give satisfactory cost-results.

TABLE 2—SHOWING DEPRECIATION ON AN ARBITRARY BASIS OF 100,000 MILES, DISREGARDING QUALITY

Make of Truck	*A*	*B*	*C*	*D*	*E*
Purchase Price	$2,550	$2,550	$2,100	$1,850	$1,200
Actual Mileage When Traded In	110,000	100,000	80,000	70,000	40,000
Estimated Depreciation per Mile; Based on 100,000 Miles	$0.0255	$0.0155	$0.021	$0.0185	$0.0120
Actual Depreciation per Mile; Based on Actual Mileage	$0.0232	$0.0255	$0.0263	$0.0264	$0.0300
Supposed Savings per Mile as Against Truck *A*	......	......	$0.0045	$0.0070	$0.0135
Actual Loss per Mile as Against Truck *A*	......	$0.0023	$0.0031	$0.0032	$0.0068

Corrections for F. D. Goll's Paper, December Journal

THE PAPER on Aluminum Alloys Used in Commercial Motor-Vehicles, by Frank D. Goll, published in the December, 1930, S.A.E. JOURNAL, beginning on p. 637, was not accurate in that the captions for Figs. 6 and 7, on p. 645, were misleading. Therefore, on p. 644, under "Aluminum Tanks" for "One of these units is shown in Fig. 6," read: This company's later train is shown in Fig. 7; then change Fig. 7 caption to read: The First Aluminum Truck-Tank Train Built in the United States, Comprising a 3330-Gal. Drop-Frame Semi-Trailer Tank and a 2873-Gal. Drop-Frame Six-Wheel Trailer-Tank, the Total Capacity of the Train Being 6200 Gal.

On page 644, second column, change Fig. 7 to read Fig. 6; and read for the caption of the illustration at the top of p. 645: Fig. 6—A 750-Gal. Capacity Aluminum-Tank, Mounted on a Drop-Frame Aluminum Semi-Trailer.

For Sale

ONE USED CAR, without piston rings,
Two rear wheels and one front spring.
Has no fenders, seat or plank,
Burns lots of gas and hard to crank.
Carbureter busted half way through,
Engine misses and hits on two.
Three years old and four in the spring,
Has shock absorbers and everything.
Radiator busted and sure does leak,
Differential's dry, you can hear it squeak.
Ten spokes missing and runs like the deuce,
Burns ether, gas or tobacco juice.
Tires all off, has been run on the rim,
A damn good car for the shape it's in.

LT. G. H. GILLETTE, QM-Res., in the U. S. Army *Speedometer*.

News of Section Meetings

(*Continued from p. 17*)

at the February meeting, at which some entertainment feature, to be announced later, will also be given.

Syracusans Hear Chase

HERBERT CHASE was the speaker at the December meeting of the Syracuse Section, which was held on the 2nd, with an attendance of 50 members and guests. Vice-Chairman Charles P. Grimes, who presided in the absence of Chairman E. S. Marks, announced that no meeting of the Section would be held in January on account of the National and local automobile shows.

Mr. Chase presented the paper entitled, Comments on American Passenger-Car Gearsets, which he gave at the 1930 Semi-Annual Meeting, supplemented with comment on the more recent developments in transmissions, and illustrated the various types and designs with lantern slides. He spoke of the increasing use of herringbone gears, the development of free-wheeling and several European usages that later may affect American practice. Regarding four-speed transmissions, he said that their evolution has been an excellent example of the compromises that are necessary between the engineering and the sales departments of motor-car manufacturers. The chief advantage of four speeds is that they make possible high road-speeds at relatively low engine-speeds. This is offset, however, in many cases, by the frequent gear-shifting required for hill-climbing and quick pick-up. The public demand for four speeds without too frequent shifting has been met by substituting a low low-speed for the former high high-speed.

Following presentation of the paper, discussion of the recent developments was entered into by most of the members present and continued after the formal meeting was adjourned and refreshments were served.

Bearings Prove Interesting

Discussed in Anecdotes and Seriously at Los Angeles After Dinner and Entertainment

BEARINGS was the theme of the monthly meeting of the Southern California Section held at the City Club in Los Angeles on Dec. 11, at which 80 members and guests listened to an interesting and informative discourse on materials, types and the manufacture and care of automotive bearings.

The affair opened with a surprise in the diminutive person of Martha Lee Sparks, the seven-year-old clever movie tot in Happy Days and in They Had to See Paris, who sang and danced for the assemblage. The feature was so favorably received that the Program Committee is considering entertainment attractions for subsequent gatherings.

Another celebrity graced the Section's board with his beaming countenance. Ralph DePalma, veteran of many hard-fought laps on the race track, entered into the spirit of the occasion by recounting the failure of a set of bearings that all but cost him the world's championship in 1912. With the laurel of victory fairly within his grasp, he suffered a bearing failure; but, with customary resourcefulness, he got out and pushed the car across the finish line for a win. The incident occurred on the Indianapolis brick track, and the mount was a Mercedes.

Another old-time happening was pulled out of the bag of racing history. It occurred in the Vanderbilt Santa Monica road race of 1913, wherein DePalma out-generaled the crafty Barney Oldfield with the aid of super-bearings and some fast thinking. The Italian pilot had fitted his racing machine with a set of bearings made by the late Kelly. These important parts were touted by the maker as being capable of functioning, if necessary, without oil. An opportunity to prove this claim came at the start of the next-to-last lap. Tom Alley, DePalma's mechanic, signaled the pit that they would stop on the next round for oil. Oldfield, 14 sec. behind, caught the signal and, on the strength of it, stopped to change a tire that was about worn down to the air. As DePalma again neared the pits for the last lap, he discovered his opponent sojourning there for new rubber; so he took the big chance, continued without oil. The bearings held and Ralph won. When examined after the race, the crankcase was found to be entirely dry.

John Wiggers, chief engineer of the Moreland Motor Truck Co., who had assisted in installing the hardy Kelly bearings in DePalma's Mercedes, was present at the recounting to back up the veteran driver's story.

Bearings and Their Care Described

The first scheduled speaker of the evening was Robert D. Pike, of the Kalif Corp., of Oakland, Calif., who presented a paper on Copper-Lead Bearings. He added comprehensiveness to his remarks by means of slides depicting bearing cross-sections, bonds and construction. The importance of the correct percentage of metals in bearing faces with reference to the amount of friction to which they are subjected was dwelt upon at length.

H. L. Hearne, of the Globe Bearings Co., of Los Angeles, spoke next, illustrating his remarks with various connecting-rod specimens. The installation and general care of bearings was his principal theme.

As a third speaker, Walter C. Fries, of the Alberg Bearing Co. of California, was introduced. He discussed roller and ball-bearings and explained the process employed by his company in reclaiming ball-bearings. The outstanding point of the discussion dealt with the proposition that a ball-bearing will serve indefinitely if protected from abnormalities.

At the conclusion of events on the program, Norman Bell, vice-president of the Alberg Bearing Co., was presented and the meeting was thrown open to general discussion on the subject. W. E. Powelson, master mechanic of the Los Angeles County Fire Department, inquired of Mr. Pike if it is true that the greater the load on the bearing, the thinner should be the copper-lead alloy. The answer was in the affirmative. The questioner also wanted to know if it is advisable to drill holes in steel-back bearings to strengthen the bond. Mr. Pike replied that this weakens the bearing.

Mr. Hearne was asked if bearings are treated to prevent rust. His answer was that bearings, before installation, are dipped in an anti-rust solution.

E. Favary, consulting engineer of the Moreland Motor Truck Co., then, upon request, read excerpts from an article on bearings and friction, written by himself and printed in the *Metropolitan Section Booster* under date of March, 1922.

Before adjourning the meeting,

Chairman F. O. Patton announced that a short course in automotive engineering about to be started by Mr. Favary will be free of tuition to members of the Society. He also announced that at the next regular meeting of the Section, which is to be held Jan. 9 in the Alexandria Hotel in Los Angeles, a featured speaker will be O. H. Ensign, of the Ensign Carburetor Co. Ralph De-Palma is also scheduled to talk about superchargers.

Crime Detection and Alloys

Unrelated Talks Hold Interest of Chicago Section Meeting with Steel Treaters' Chapter

RESEARCH is a subject in which members of the Society logically are interested, but the interest of the Chicago Section members was directed along an unusual but not inconsistent line at their December meeting, at which they listened intently for nearly an hour to an exposition of laboratory methods of crime detection. The second principal address of the evening was also highly technical but on a less spectacular subject—that of the technical properties of the iron-nickel-chromium system—which was presented for the special information of the steel treaters in attendance.

The occasion was a joint meeting of the Chicago Section of the S.A.E. and the Chicago Chapter of the American Society for Steel Treating, and was held on Dec. 11 at the City Club. A total of 220 members and guests of the two organizations were in attendance. The dinner preceding the technical meeting was enlivened by a program of singing and dancing numbers given by "Miss Omaha" and by the "Gypsy Dancing Girl." The entertainment was provided by courtesy of the Chicago Section, S.A.E., and was much enjoyed.

Following the dinner, D. L. Colwell, chairman of the Chicago Chapter of the A.S.S.T., extended the thanks of the chapter for the entertainment and spoke of the close harmony and good-will existing between the local groups of the two societies, mentioning specifically the present officers of the Chicago Section of the S.A.E.: E. W. Stewart, Otto R. Schoenrock, and C. J. Blakeslee, and last year's Chairman, D. P. Barnard, 4th, who was also present.

Laboratory Method of Crime Detection

President Robert Guthrie, of the A.S.S.T., upon request of Mr. Colwell, briefly reviewed the progress of the National steel treaters' society and pointed out the values that attach to scientific research through the leveling of the curves of production in the industry.

The next speaker presented by Chairman Colwell was Col. Calvin Goddard, of the scientific crime-detection laboratory of Northwestern University, who held the undivided attention of the audience for the better part of an hour, talking of the research being done to further the quick apprehension and conviction of criminals.

Colonel Goddard said that cases of a wide diversity are handled by the laboratory, including the identification of guns from which fatal bullets have been fired, use of the "lie detector" and of "truth serum," identification of handwriting and of textiles, and the making of casts from a substance called "mulage" which has been useful in indefinitely preserving human faces, forms and characteristics.

At the conclusion of Colonel Goddard's talk, the gavel was passed to E. W. Stewart, Chairman of the Chicago Section, S.A.E., who handed a bouquet back to the steel treaters in a brief comment on the privilege of meeting jointly with the Chicago Chapter, A.S.S.T., and of the cordial relations that have always existed between the two organizations. Jerome Strauss, chief research engineer of the Vanadium Corp. of America, was then introduced.

Steel Alloys and Their Uses

Mr. Strauss's extemporaneous talk on the properties of the alloys of the iron-nickel-chromium system was profusely illustrated with slides. The speaker discussed successively iron-chromium, iron-nickel, iron-chromium-nickel and high-nickel alloys. He pointed out that none of the low-chromium steels show great strength at high temperatures; for instance, valve steel for internal-combustion engines is selected for its resistance to oxidation rather than for any particular strength quality. The whole talk dealt with the ability of the various steels to resist corrosion rather than stresses and the application of the alloys to commercial uses, the contents of iron, chromium and nickel in steel varying according to the uses to which the metal is to be put.

Corrosion resistance of steel under ordinary conditions and under conditions of high acidity was thoroughly discussed by the speaker.

The meeting was not adjourned until 11.30 p. m., discussion being dispensed with because of the lateness of the hour. Members of both organizations were unanimous in agreeing that the evening had been a most successful one in every respect.

Engine Research and Testing

Two-Cycle-Development Study and Aircraft-Engine Tests Described at Baltimore

TWO good addresses were heard by more than 100 members and guests of the Baltimore Section at the meeting at the Lord Baltimore Hotel on Dec. 10. One was on Aircraft-Engine Testing, which was given by T. T. Neill, of the aeronautic section of the Bureau of Standards, and the other was on New Developments in Fuel Injection on Two-Cycle Engines, read by Walten B. Robe, consulting automotive engineer of Baltimore. The gathering, presided over by Chairman G. O. Pooley, was a most representative one as regards the allied motor-vehicle and aeronautic interests.

A guest of the evening was John A. C. Warner, General Manager of the Society, who, in a brief address, outlined certain of the functions of the Society and expressed his gratification at the excellent progress the year-old Section has made in increasing its membership from 24 to 80 in eight months. He presented a short résumé of the aeronautic activities of various other Sections and recounted the history of the merging of the former American Society of Aeronautical Engineers with the old Society of Automobile Engineers in 1916.

Laboratory versus Flight Tests

Mr. Neill described the various engine-testing methods used by the Bureau of Standards and explained the tests that all aircraft engines must undergo before official approved-type certificates are issued to the manufacturers. He said in part:

Strange as it may seem, many people overlook the fact that the way to tell how an engine will run is to run it. However, to run an engine in flight service to determine its airworthiness is not practical. That can

better be determined on the ground. The testing of an engine by flying it a great deal will give information if the engine is flown enough, but the result is rather deceptive and flight conditions are very difficult to control. Therefore, this form of testing is not a substitute for dynamometer or torque-stand or fixed-engine test-stand work. We have had a number of engines submitted for approval that have had very little block testing, if we use that term in the general sense, although they had considerable flight testing. In general, engines of this type do not run through their Bureau tests successfully.

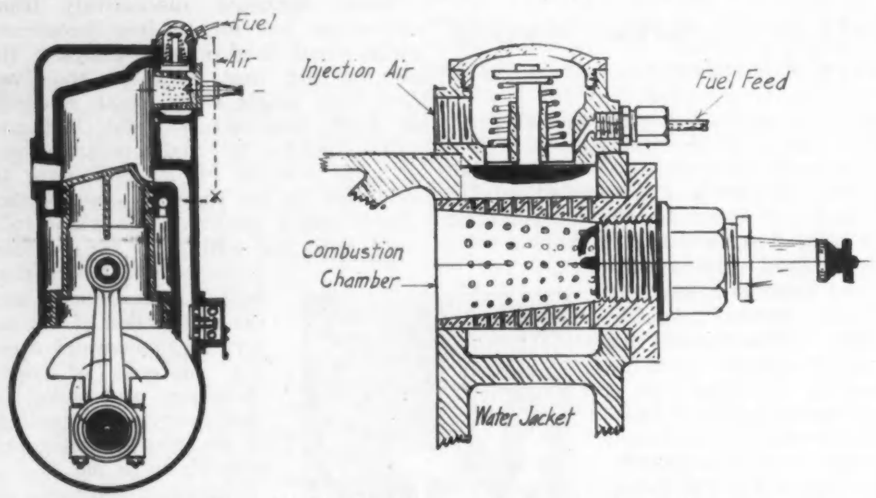
Our test is a 50-hr. endurance test which is more or less standard as a criterion of the performance of an engine, but 50 hr. in the air does not compare with the same period on the stand. I am afraid that many manufacturers are deceived in that respect. They will hop around a little bit with the engine in a ship and test the engine under real flight conditions to see how it performs, but not test it on the ground. I recall several cases of certain engines, built by reputable companies that I know have competent engineering staffs, that were disapproved. These engines were given very satisfactory flight tests but had not been given much dynamometer or torque-stand work.

Although test equipment is not excessively expensive and need not be complicated, many manufacturers do not have what could be called adequate test equipment. The best equipment, such as dynamometers and the necessary cooling fans, may be expensive, but a torque stand is relatively cheap and, with its necessary accessories, can be made quite accurate. All of our Department of Commerce tests are being run on torque stands and they have been very satisfactory.

Following Mr. Neill's address, various lantern slides were shown of different types of engines which have passed or failed in the Bureau's tests, of the torque stand, the engine-control rooms and of engine parts that broke under tests.

Two-Cycle-Engine Improvement

A two-cycle engine that the designer, E. W. H. Williams, believes is much superior to the four-cycle engine was described and illustrated in a paper read by Mr. Robe. It is the result of four years of research and test work that is not yet completed, although the results so far obtained are of engineering interest. The speaker gave a comparison of the operating cycle of two and four-stroke engines and cited N.A.C.A. Report No. 239 on a test at the Langley Memorial Laboratory of a single-cylinder 5 x 7-in. two-cycle engine in which the fuel injection was through the intake port. This developed 53 b-hp. at 1300 r.p.m. when operated on the two-stroke cycle but only 27.5 b-hp. when operated as a four-stroke engine at the same speed.



CYLINDER AND FUEL-INJECTION UNIT OF WILLIAMS TWO-CYCLE ENGINE

The real cause of the failures of two-cycle engines in idling and under light loads was said to be that, when throttled, sufficient inert gas passes back through the exhaust port to produce constant volume, although the engine is of the constant-compression type. At the beginning of his tests the investigator built several separate superchargers or scavenging pumps with auxiliary air-injection pumps and, after much labor and grief, found that he could secure higher mechanical efficiency, together with low first cost, with a power cylinder of conventional design having intake and exhaust ports at the lower ends of the piston stroke. The piston is of the step type, the larger-diameter lower step-cylinder being approximately of the same volume as the power cylinder. The crankcase is closed and has suitable intake and discharge valves and passages. By increasing the volume of the step-cylinder, any desired degree of supercharging can be secured, with a corresponding increase in scavenging air.

A unique and highly important detail is the fuel-injection device provided at the top of the combustion-chamber on the side of the cylinder. This consists of a tube open to the combustion-chamber and having a spark-plug in its outer end. The tube is enclosed in an air chamber and is drilled with a series of air holes, forming a Davy-lamp type of screen. Above the tube is an automatic intake check-valve operated by the injection air; and above this is the fuel-feed check-valve, which is fed from a variable-stroke fuel-pump. Fuel is deposited in a liquid state on top of the air check-valve when the power piston is on its downward stroke.

This special construction is said by the inventor to give a prolonged injection effect, so that, after firing of the charge, the engine produces an indicator card approximately like that of the Diesel engine, the prolonged burning of the mixture extending the peak pressure well toward the maximum piston stroke.

An engine embodying these characteristics is soon to be put to its final tests. The designer asserts that he has found it to be not only highly efficient but to have the ability to burn much lower grade fuels than is possible with any other type of engine except the Diesel.

Following a program of entertainment, arrangements for which were made by A. Bruce Boehm, chairman of the Program-Reception Committee, the meeting adjourned.

Car and Airplane Tires

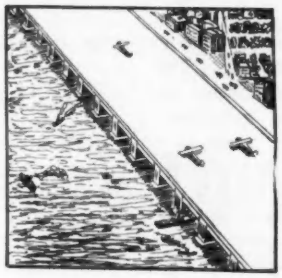
Higher Road Speed Partly Offsets Economy from Improved Product, St. Louisans Hear

ONE and one-half cents per 100 miles is the expected figure of automobile-tire cost today, whereas in the early days of the automobile the common cost was 11 cents per 100 miles. On the other hand, road speeds and acceleration made possible by the increased horsepower of cars has greatly increased the tread wear on tires.

These were important points brought out in a paper on pneumatic tires that was presented by C. D. Smith, manager of the development department of the Firestone Tire & Rubber Co., at the Dec. 9 meeting of the St. Louis Section, which was attended by 55 members and guests.

Following the reading of minutes of the November meeting, several letters addressed to the Society were read. One of these was a proposal to act officially upon a recommendation made by Past Chairman W. L. Dempsey to the Joint Engineering Council of St. Louis to disapprove the proposed act before the Missouri Legislature to license

engineers practising in the State. After discussion, the meeting voted to support Mr. Dempsey and directed that a letter to this effect be sent to the president of the Engineering Council.



Speaking of present automobile tires as compared with those of 1910, Mr. Smith stated that more mileage and consequently greater economy are obtained because not only of the changes in design from small to large cross-section but of better manufacturing methods. Four-ply balloon tires that formerly were adequate have generally been displaced by six-ply tires that are stronger and have longer life. The tire designer has been faced with the difficulty created by the general trend toward increased power of cars. Ten popular makes of car average 61 per cent increase in brake horsepower, according to the speaker. The resulting quick acceleration and high road-speeds are reflected in greatly increased tread wear of the tires. Tests made at Washington State College show that tires wear 1½ times as much at 40 m.p.h. as at 20 m.p.h. Another test made at the same college showed 65 per cent less tire wear on an 80-hp. car than on one of 125 hp.

Other factors that enter into tire life are the unsprung weight, the brake effectiveness, heating of the tires, and sprung frames and axles. In motorcoach operation, the heat from the brake-drums is radiated directly or conducted to the tire, where it will eventually decrease the life of the tire by either overcuring the rubber or increasing the air pressure to the extent that the tire will blow out prematurely.

Requisites of Airplane Tires

An airplane tire, continued Mr. Smith, is expected to cushion the shock while landing and taking off, to adhere to the ground during braking, and to reduce friction in the tail, where tail wheels are used. It must withstand the effects of slipping on the ground during acceleration of the wheel when landing. It must resist abrasion, laceration and, most important, must not blow out under shock. Smooth treads are permissible on these tires, but antiskid treads do not greatly increase the parasitic drag. Tests on a popular plane showed the effect on speed of antiskid tires over smooth tires to be ¼ m.p.h. at 125 m.p.h.

As on the early automobile, clincher tires were used on the first airplanes. They were hard to mount and were not very effective in absorbing the shock. These gave way to a straight-side drop-center rim and later to the "doughnut" full-balloon tires. These air balloons entirely eliminated ground-looping, because the ground contact provides resistance to a change in direction. The large area of contact conforms to irregularities in the landing-field. The large projected area of these small-diameter tires is not important, as the streamline effects practically neutralize the effect of the larger frontal area. There is a general trend toward the use of tires fore and aft, to eliminate the tearing effects of the tail-skids on the surface of the landing-field, when airplanes are taking off, landing and taxiing.

Daytonians Go Night Driving Vicariously

LIGHT was thrown on night driving at the Dec. 11 meeting of the Dayton Section by W. M. Johnson, of the National Lamp Works of the General Electric Co., in Cleveland, who presented to the Dayton members the same illustrated paper that he gave in October at the meeting of the New England Section, as reported in the S.A.E. JOURNAL for November, p. 526.

The speaker was introduced by Chairman Carl Kindl, and the address was exceptionally well received. Mr. Johnson demonstrated, with two laboratory model head-lamps, the methods used in designing lenses so as to obtain the desired light distribution. Discussion brought out details involved in the automobile headlighting problem that were not dealt with in the paper.

At a brief business meeting following the members' dinner, Vincent G. Apple was elected Dayton Section representative on both the Nominating Committee and the Sections Committee of the Society.

Draftsmen Evolve New Ideas Moore Tells Milwaukeans

FOR a draftsman to be caught loafing, even if he is waiting for his superior to check a specific job that has been finished, is regarded as a crime of the highest order in the Nash organization, Meade F. Moore told more than 80 members and friends of the Milwaukee Section at the Milwaukee Athletic Club. The talk by Mr. Moore, chief engineer of the Nash Motor Co., was on the subject, Some Commercial Aspects of Automotive Research. The meeting followed the usual monthly dinner and entertainment, which were attended by nearly 60 persons.

The draftsman's alternative in the circumstances is to keep his mind and his pencil and slide rule busy on any odd problem of which he happens to think. In this way, said Mr. Moore, many revolutionary ideas have been developed into practical devices. A rule of the company, however, is that no one shall be censured for making a mistake.

Mr. Moore divided research into two general classifications: true research, or that which has to do with more or less unknown laws, and commercial development, in which the known laws of nature are applied to some specific problem. He pointed out that industry in general has not reached the point where it appreciates the benefit that accrues from true research and that this work has to be carried on by idealists or men of the college-professor type who rarely receive adequate compensation for their work.

Even commercial research which actually develops improvements in the product has its financial problem, said the speaker, who stated, however, that in his experience the best method is to determine the cost of running the department by the month and then distribute this monthly expenditure over the number of units built per month.

At the conclusion of Mr. Moore's talk, helpful comments were made by other members of the Nash organization, including E. G. Dunn and D. W. Averill. They pointed out that parts manufacturers have contributed a great deal to research work in the development of units such as brakes, transmissions and steering-gears.

One member, in commenting upon the need of thorough testing of automobiles in the hands of the public, suggested that the best possible test is to turn a car over to a woman to drive on a zero morning. "You will find out that way just how good your product is," he said. He also suggested a whistle on the emergency brake, which would sound when an owner attempted to drive the car with the brakes set; and also, for women drivers, a magnetic device in the gasoline tank which would send the car to a filling station when the tank was nearly empty.

While these suggestions are somewhat fantastic, they do point to the need of studying practical difficulties into which car owners get by reason of their inexperience.

Wichita Section Flies to Tulsa

WHAT is probably the first occasion on which those attending a Section meeting flew to the meeting place and returned by the same means was the December meeting of the Wichita Section, which was held at Tulsa,

Okla., on Dec. 13. Six airplanes loaned by various manufacturers left the Municipal Airport at Wichita about 1 p.m. with 22 Section members aboard. Rex B. Beisel, vice-president and chief engineer of the Spartan Aircraft Co., welcomed the fleet upon its arrival, and the afternoon was devoted to an inspection trip through the Spartan plant.

Supper was served in the Spartan cafeteria at 7 o'clock and, after that had been disposed of, the paper of the evening on The Management of an Aircraft Engineering Department was presented by Mr. Beisel.

Favors Divisions in Engineering Department

According to the author, the department personnel should be separated into units whose functions and duties are clearly defined, with responsibilities placed and fixed accordingly. He also favors providing detailed instructions and procedures for standard engineering and drafting-room practices, and also the use of forms and blanks that will result in the most efficient performance of these instructions and procedures. An ideally organized department would be divided into a design section, a structural section, a weight section, a material and specifications section, an aerodynamics section, project engineers and draftsmen. The duties of these various divisions, as well as those of the chief engineer, were clearly outlined in the paper.

The use of standardized sizes of tubing was emphasized by Mr. Beisel. In the smaller sizes the diameters should differ by 1/16 in., this increment becoming ⅛ in. as the diameter increases, and for the larger diameters the difference should be ¼ in. Following such a practice would eliminate the odd sizes of tubing that now make necessary the carrying of an excessive stock of material. The inspection department should, in his opinion, be under the control of the chief engineer, since its function is to see that the shop carries out the orders received from the engineering department.

The return trip was made by airplane the next morning, the craft landing just as the first snowfall of the year began. The trip was so successful that the Section hopes to fly to Kansas City or repeat its visit to Tulsa in the near future.

Free-Wheeling Correction

OUR attention has been called to an error in the news report of the October Metropolitan Section meeting, as reported in the S.A.E. JOURNAL for November, p. 621.

Mention was made of the Joseph and the Humfrey-Sandberg designs, saying that both of them embody multiple-roller cams. As will be seen from the full text of the paper which Mr. Roos read at that meeting, as it appears on p. 31 of this issue of THE JOURNAL, the rollers in the Humfrey-Sandberg design are not acted upon by cams but secure their wedging action from their diagonal position between conoidal races.

Automobile Traffic Rules in Seoul, Korea

FOLLOWING are the automobile traffic rules of Seoul, Korea, in the English version issued officially for foreigners:

(1) At the rise of the hand of the policeman stop rapidly. Do not pass him or otherwise disrespect him.

(2) When a passenger of the foot hove in sight tootle the horm trumpet to him melodiously at first. If he still obstacles your passage tootle with vigor and express by word of mouth the warning "Hai, Hai!"

(3) Beware of the wandering horse that he shall not take fright as you pass him. Do not explosion the exhaust pipe. Go soothingly by him or stop by the side till he pass away.

(4) Give space to thè festive dog that make sport by the roadway. Avoid entanglement with your wheelspoke.

(5) Go soothingly on the grease mud as there lurk the skid demon.

(6) Press the brake of the foot as you roll around the corner to save the collapse and tie up.

Know Where They Are?

IF ANYONE knowing the present address of any one or more of the members of the Society listed below will send the address to the office of the Society at 29 West 39th Street, New York City, the courtesy will be much appreciated. Copies of the S.A.E. JOURNAL sent to the addresses given have been returned as undeliverable. The Society desires present addresses for revision of the 1931 Roster of members and for its mailing list for the S.A.E. JOURNAL and other publications.

Members Whose S. A. E. JOURNALS Have Been Returned Because of Incorrect Addresses

ARCHIBALD, J. R. (A) manager, Bothwell Motors, Ltd., Wheat Pool Bldg., *Regina, Saskatchewan, Canada.*

BRETH, J. P. (A) special representative, salesman, Wayco Oil Corp., 15th and Warren, West, *Detroit.* (mail) 2750 West Chicago Boulevard.

BUTLER, ROBERT W. (J) engineer, Treiber Diesel Engine Corp., Camden, N. J. (mail) 136 White Horse Pike, *West Collingswood, N. J.*

DYE, KENNETH R. (A) motorcoach body designing, Chrysler Corp., Dodge Division, *Detroit.* (mail) 250 East Grand Boulevard.

DYER, RAYMOND W. (M) mechanical engineer, Keyes Fibre Co., Inc., *Waterville, Maine.* (mail) 6½ Elm Terrace.

FANNING, GEORGE H. (A) representative, Fate-Root-Heath Co., 50 Church St., *New York City.*

FRY, H. DELONG (A) president, H. DeLong Fry & Co., 1776 Broadway, *New York City.*

GRIFFIN, NICHOLAS M. (A) vice-president, Mack-International Motor Truck Corp., New York City. (mail) 3300 Wentworth Avenue, *Chicago.*

GUY, FLOYD (J) full-size-body draftsman, Pierce-Arrow Motor Car Co., *Buffalo;* (mail) 159 Virgil Avenue.

HEBNER, ALFRED K. (A) 1 Old Army Road, *Scarsdale, N. Y.*

HOWELL, HORACE L. (F M) transportation engineer, General Motors Export Co., Sao Paulo, Brazil. (mail) General Motors Export Co., 1775 Broadway, *New York City.*

HULTON, RALPH (J) sales manager, Lovejoy Mfg. Co., Boston. (mail) 19704 Roselawn Avenue, *Detroit.*

JOHNSON F. M. (A) sales engineer, Dayton Steel Foundry Co., *Dayton, Ohio.*

JUDD, DONALD M. (A) Moto-Meter Gauge & Equipment Corp, 8-228 General Motors Building, *Detroit.*

KILROE, HARRY B. (M) factory manager, Outboard Motors, Inc., 1865 27th Street, *Milwaukee.*

KOIDZUKA, SHICHIBEI (F M) general service manager, Toho Automobile Co., Ltd., Tokio, Japan. (mail) 673, Iriyamazu, Iriarai-machi, Tokio-fuka, *Japan.*

KRAGNESS, EDWARD O. (A) Hotel Brownell, 335 Larkin Street, *San Francisco.*

LANE, F. VAN Z. (M) vice-president, engineer, Equitable Coach Co., Inc., 33 Liberty Street, *New York City.*

LAPORTE, N. EMILE (A) 7836 De Gaspe, *Montreal, Quebec, Canada.*

LARKIN, ANTHONY J. (J) service engineer, Sky Specialties Corp., 3651 Hart Avenue, *Detroit.*

LUCAS, ANTHONY F. G. (A) Racquet Club, *City of Washington.*

MILLER, J. A. (A) president, treasurer, Erie Rubber Corp., First Street, *Sandusky, Ohio.*

MILLER, JOHN M. (M) field manager, Westchester Airport Corp., *Armonk, N. Y.*

MOON, STANLEY (A) secretary, vice-president, Moon Motor Car Co., 4400 North Main Street, *St. Louis.*

NEWTON, RICHARD T. (F M) chairman, board of directors, Newton, Pollock, Ltd., 129 Gannon Street, *London, E. C. 4, England.*

OSBORN, PAUL VICTOR (A) associate general manager, Continental Motors Corp., *Detroit.*

PALMER, SEYMOUR CARLOS (A) training commercial-car sales engineers, General Motors Export Co., General Motors Building, *New York City.*

PARKER, VICTOR C. (M) care William Beaumont General Hospital, *El Paso, Texas.*

PERRY, ROBERT J. (A) production manager, Mich-La Lumber Industries, Inc., Shreveport, La. (mail) *Grand Blanc, Mich.*

PRICE, CHARLES S. (M) president, Art Metalabel Corp., *York, Pa.*

SAY, F. M. (A) base maintenance manager, New York, Rio & Buenos Aires Line, Inc., Port-of-Spain, Trinidad, B. W. I. (mail) New York, Rio & Buenos Aires Line, Inc., *Miami, Fla.*

SILBERMAN, JACOB A. (A) president, Chevron Motors Corp., 14 West 17th Street, *New York City.*

SWANK, A. L. (M) sales manager, Long Mfg. Co., 2768 East Grand Boulevard, *Detroit.*

THOMAS, HARRY M. (A) superintendent, Ann Arbor Machine Co., *Shelbyville, Ill.* (mail) 2213 South First Street.

THOMSON, J. E. (A) manufacturers' sales representatives, Firestone Tire & Rubber Co., 4264 Woodward Avenue, *Detroit.*

TITTENSOR, PERCY (A) experimental engineer, Mitchell Camera Corp., West Hollywood, Calif. (mail) 634 Dayton Street, *Flint, Mich.*

WARREN, GEORGE HENRY, JR. (A) stock broker, New York Stock Exchange, New York City; (mail) *Tuxedo Park, N. Y.*

WETZLER, LESTER EDWARD (J) layout man, chassis and engine, Pierce-Arrow Motor Car Co., *Buffalo;* (mail) 15 Wingate Avenue.

WILLIAMS, C. C., MAJOR-GEN. (S M) War Department, Chief of Ordnance, *City of Washington.*

ZUFALL, EARL T. (A) mechanic, Pickwick Stages, Inc., *Los Angeles;* (mail) 3245 East Fourth Street.

W. J. P. Moore

ONE of the earliest Members of the Society, W. J. P. Moore, who became a Member in 1905, has passed away at Detroit after a long and active career in the automotive engineering world.

Mr. Moore was educated in Yale University at New Haven, Conn., receiving his degree in Mechanical Engineering from the Sheffield Scientific School. Immediately after being graduated he entered the employment of the Hartford Engineering Co., of Hartford, Conn., with which he remained for two years. He then joined the Worthington Pumping Engine Co., of London, England, and was given complete charge of the company's European business. At the time of his entering the Society, he was vice-president of the Worthington Automobile Co., of New York City and New London, Conn.

In 1910, Mr. Moore had a consulting engineering practice in Pittsburgh, and in 1914 he joined the Alberger Pump & Condenser Co., of New York City. Three years later he abandoned business for a time, making his residence in New York City, but in 1921 he resumed his consulting engineering practice, which he continued for six years, after which he permanently retired from the business world in 1927.

Besides being a Member of the Society for 25 years, Mr. Moore was a member of the Metropolitan Section of the Society and also a member of the following societies: American Society of Mechanical Engineers; Institution of Civil Engineers, England; Institution of Mechanical Engineers, England; Institution of Naval Architects, England; and Verein Deutscher Ingenieure, of Berlin, Germany.

Joseph A. Williams

JOSEPH A. WILLIAMS, for the last 21 years a Member of the Society, passed to his rest on Nov. 2. Born in Columbus, Ga., in 1870, and graduated from the Alabama Polytechnic Institute with the degree of Mechanical Engineer, Mr. Williams was, for 25 of his 40 years in the business world, president of the K-W Ignition Co., of Cleveland. He embarked on his commercial career with the Brush Electric Co., and later joined the Cleveland Electrical Mfg. Co. In 1893 he affiliated himself with the Independent Telephone Co., with which he remained until the organization of the K-W Ignition Co., of which he was elected president.

Mr. Williams was elected to membership in the Society in 1909, and was a member of the Cleveland Section. He presented a paper entitled, Magneto versus Battery Ignition, at a meeting of the Minneapolis Section which appeared in THE JOURNAL for December, 1917, p. 375, and in TRANSACTIONS for 1917, Part 2, p. 434.

Harry J. Haon

THE passing of Harry J. Haon, assistant division manager of the Fabrikoid division in Fairfield, Conn., of E. I. duPont de Nemours & Co., Inc., to his final rest on Nov. 6 is announced with sincere regret.

Mr. Haon was born in Chicago in 1870 and received his higher education in the New York City High School and various polytechnic schools. He entered the business world in 1890 as assistant in the advertising department and in charge of demonstration and exposition advertising for the W. K. Fairbanks Co., a position which he held until 1896. At that time he joined the American Prgamai Co. and the Fobsikai Co., which later were succeeded by E. I. duPont deNemours & Co. Mr. Haon became successively superintendent and plant manager, promotion manager and assistant division manager for the duPont company and remained with it until his recent death.

Mr. Haon was elected to Associate Membership in the Society in 1924, and was a member of the Metropolitan Section.

Meetings of the Society

(Concluded from p. 4)

lumbus Hotel, in Miami, the evening of Jan. 8, the first day of the races, at 7.30 o'clock. Lieut. James Doolittle, of the Shell Petroleum Corp., will act as Toastmaster, introducing as speakers Igor Sikorsky, vice-president Sikorsky Aviation Corp., and Major Leighton Rogers, of the Department of Commerce.

As the races this year are attracting pilots and aeronautic men from all over the Country, it is believed that the Society dinner will further its activities in the aeronautic industry.

19th National Aeronautic Meeting

Plans for the 19th National Aeronautic Meeting are proceeding rapidly and the choice of papers, while not as yet definitely settled, has been indicated by the Aircraft and Aircraft-Engine Committees. The meeting will be held in Detroit on April 15 and 16 and will have six technical sessions, followed by a joint National Aeronautic Dinner of the Society and the Aeronautical Chamber of Commerce on the second evening. The technical sessions will be in the Crystal Room, and the dinner in the Grand Ballroom of the Book-Cadillac Hotel.

The program, as outlined to the time of writing, includes papers on the vertical wind tunnel, corrosion prevention, superchargers, bearings and bearing loads, and a very interesting presentation by Igor Sikorsky of the findings of his research on flying-boat hull models. Further information regarding the program will be given in succeeding issues of THE JOURNAL.

Personal Notes of the Members

Olley with Cadillac

Maurice Olley, who recently joined the engineering staff of the Cadillac Motor Car Co., of Detroit, owes this position to his extensive and thorough experience in high-class automotive fields, having been connected with Rolls-Royce of America, Inc., since 1919.

After preliminary training at the University of Manchester and the Birmingham Technical College in England, he became connected, in 1908, with H. W. Ward & Co., Ltd., machine-tool manufacturers in Birmingham. He had advanced to the post of chief tool draftsman when, in November, 1912, he accepted the position of factory-equipment draftsman with Rolls-Royce, Ltd., of Derby, England, and by July, 1917, rose to the position of personal draftsman and designer to Sir Henry Royce. He was then sent to this Country to take charge of the technical manufacturing development of Rolls-Royce aircraft engines in the United States. From 1919 until some weeks ago he held the position of chief engineer of the chassis division of Rolls-Royce of America, Inc.

A member of the Society since 1921, he has been active in the New England Section. He is the author of a paper entitled, Comparison of European and American Automobile Practice, which appeared in THE JOURNAL for August, 1921, p. 109., and in TRANSACTIONS for 1921, part 2, pp. 418 to 442.

Harold Nutt Joins Borg & Beck

Harold Nutt, who has been during the past eight years successively engineer, assistant chief engineer and chief engineer of Durant Motors, has announced his resignation to accept a position as director of engineering for the Borg & Beck Co., division of the Borg-Warner Corp., of Chicago.

Mr. Nutt was born in 1893 at New Rochelle, N. Y., and was graduated in mechanical engineering from Worcester Polytechnic Institute in 1916. During the next three years he worked for the B. F. Sturtevant Co., of Hyde Park, Mass., beginning as assembler and rising until, as assistant chief engineer, he had charge of experimental work in connection with new design and special apparatus. During 1919 and 1920 he was engineer in the railway motor-car department of Fairbanks, Morse & Co., in Chicago.

In 1921 Mr. Nutt formed a connection with the Premier Motor Corp., of Indianapolis, and two years later became engineer for Durant Motors, at the Long Island City plant. He remained with the Durant organization for nearly eight years, serving successfully at Elizabeth, N. J., and Detroit.

Mr. Nutt became a Member of the Society in 1919, and is a member of the Detroit Section. He is one of the authors of a paper on A Four-Speed Internal-Underdrive Transmission, which was published in THE JOURNAL, Feb., 1927, pp. 246-254, and in TRANSACTIONS for 1927, part I, pp. 158-170.

Irving Reuter Heads Oakland

On Oct. 15, Irving J. Reuter, who for the last four years had been president of the Olds Motor Works, of Lansing, Mich., assumed the presidency and general managership of the Oakland Motor Car Co., of Pontiac, Mich.

After being graduated from Purdue University in 1907 with the degree of B.S.M.E., Mr. Reuter became design draftsman for the Overland Auto Co. His working and executive capacity is well illustrated by the fact that two years later he joined the Remy Electric Co., of Anderson, Ind., as chief engineer and, after serving as production manager, general superintendent and general manager, became president of that company in 1922. In 1926 he was called to fill the aforementioned directing position with the Olds organization.

Mr. Reuter has been a member of the Society since 1922, during which time he was also a member of the Indiana Section until 1926, when he transferred his Section membership to the Detroit Section.

Cooperative Fuel-Research Endorsed

Leaders of the automotive and oil industries, at a meeting held Dec. 3 in the Metropolitan Club, New York City, gave a "vote of confidence" to the fuel-research work carried on by the United States Bureau of Standards, in cooperation with the Society, the American Petroleum Institute and the National Automobile Chamber of Commerce.

Together with numerous prominent oil-company executives who were present were the following members of the Society:

A. J. Brosseau, president Mack Trucks, Inc.

Roy D. Chapin, Past-President, chairman Hudson Motor Car Co.

Alvan Macauley, president Packard Motor Car Co., and president National Automobile Chamber of Commerce.

Alfred Reeves, general manager National Automobile Chamber of Commerce.

Alfred P. Sloan, Jr., president General Motors Corp.

In addressing the assembly which endorsed the American Automobile Association in its protest against any further imposts on the motorist, either in the form of registration fees or gasoline taxes, Mr. Chapin pointed out that in the last 10 years motor-vehicle levies have been increased more than 500 per cent as compared with an increase of about 160 per cent in motor-vehicle registration and about the same increase in highway expenditure.

"Of late," he continued, "there have been too many demands to increase these taxes and too many attempts to divert the funds to other purposes. In some States the automobile funds are used, or planned to be used, for such things as public buildings, local schools, city streets, port expenses, and sea wall and flood damage. Diversion to other uses of money paid as motor-vehicle taxes is particularly unjustifiable.

"This year, motorists will pay special taxes in excess of $1,000,000,000, while the highway program cost will be approximately $1,500,000,000, showing that, while everyone benefits from highway construction, one class of people, the motor-vehicle owners, pay two-thirds of the cost in special taxes aside from their participation in the balance."

The gathering voted to continue the fuel-research work, which has brought many important developments in the last seven years that have increased the efficiency and economy of motor-vehicle operation.

Alexander P. Bartusch has recently accepted a post as mechanical engineer and designer in rolling-mill equipment with the Dneprostal Metallurgical Works, of Pittsburgh. His previous connection was with the S. Diescher & Sons Co., consulting engineers, of Pittsburgh, for which he was a designer.

David Beecroft, of the Bendix Aviation Corp., in New York City, has been named a vice-president of the Motor and Equipment Association in charge of Division A, and also was elected to the board of directors of that association.

Louis W. Blauman has been promoted from his post as sales engineer for the Doehler Die-Casting Co., in Toledo, Ohio, and is now serving that company as its western sales manager, with headquarters in Detroit.

Hermann Boysen, layout draftsman for the Reo Motor Car Co., of Lansing, Mich., recently began his service with that company after leaving the employment of the American Cirrus Engines, Inc., of Marysville, Mich.

(*Continued on p.* 40)

Applicants Qualified

The following applicants have qualified for admission to the Society between Nov. 10 and Dec. 10, 1930. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

ARNOLD, FRED J. (J) master mechanic's office, John Morrell & Co., *Ottumwa, Iowa;* (mail) 432 East Fourth Street.

BJORKMAN, A. (F M) research engineer, Spontan Transmission Co., Stockholm, Sweden; (mail) care A. B. Spontan, *Stockholm 7, Sweden.*

BUGBEE, JAMES TAYLOR (J) experimental engineer, Tillotson Mfg. Co., *Toledo, Ohio;* (mail) 337 West Central Avenue, Apartment 202.

CHRISTENSEN, MARTIN P. (J) service manager, Jacobson Mfg. Co., *Racine, Wis.;* (mail) 1308 Lathrop Avenue.

COLVIN, FRED H. (M) editor *American Machinist,* McGraw-Hill Co., 475 Tenth Avenue, *New York City.*

CRAIG, WALTER G. (A) division lubricants representative, General Petroleum Corp. of California, 1709 West Eighth Street, *Los Angeles.*

FORMANEK, EDWARD (A) associate of firm, E. & J. Frohlich, Dlouha 35, *Prague 1, Czechoslovakia.*

FRAZER, ARTHUR W. (A) president, Auto Starter Co., Ltd., *Toronto, Ontario, Canada;* (mail) 470 Glenlake Avenue.

FRISCHKORN, PAUL EWALD (M) body die designer, Fisher Body Corp., *Detroit;* (mail) 636 West Hollywood.

GUENTHER, CARLTON A. (A) general manager, Jacobs Transfer Co. of Baltimore, 25 East Lee Street, *Baltimore.*

GWYN, CHILDRESS BUCKNER, JR. (M) contact engineer, in charge of electrical contact, research and production, P. R. Mallory & Co., Elkon Division, *Indianapolis;* (mail) 1461 Drexel Avenue.

HAAYS, HARRY CECIL (F M) mechanical engineer, Transport Department, *Wellington, New Zealand.*

HUBBARD, REGINALD KIRSHAW, Major (F M) Royal Army Service Corps, Technical Committee, Mechanical Warfare Board, Woolwich Arsenal, *London, England.*

KNIGHT, RUFUS HAYWARD (A) industrial representative, Celotex Co., *Detroit;* (mail) 10410 East Jefferson Avenue.

KOCH, ALFRED S. (A) vice-president, general manager, Mohawk Aircraft Co., Municipal Airport, *Minneapolis;* (mail) 2220 Irving Avenue, South.

KUSUYAMA, KENJI (A) commercial-car specialist, sales representative, General Motors, Japan, Ltd., *Osaka, Japan;* (mail) 1718 Nishinobo, Ashiya, Mukogun, *Hyogoken, Japan.*

MAGNESS, LAURANCE FARNANDIS (M) president, Hercules Power Gasoline Co., *Baltimore;* (mail) 3224 Ellerslie Avenue.

MCCORMICK, GEORGE DANIEL (J) engineer, Thompson Products, Inc., *Detroit;* (mail) 17367 Monica Avenue.

MILLER, WELLS B. (A) district service manager, The White Co., 708 East 25th Street, *Baltimore.*

MOSTING, RUDOLF HERMANN (F M) chief engineer, manufacturers' service division, Deutsche Vacuum Oel Aktiengesellschaft, *Hamburg, Germany;* (mail) Semperhaus B, Spitalerstrasse 12.

NEMETZ, CHARLES (F M) chief engineer, Denes & Friedmann, A. G., Mitterbergg II, *Vienna, XVIII, Austria.*

O'DONNELL, JAMES H. (A) service manager, Mack International Motor Truck Corp., 1210 East 20th Street, *Baltimore.*

ORDORICA, MIQUEL (J) junior engineer, International Motors, Mack Trucks, Allentown, Pa.; (mail) 615 South Second Avenue, *Highland Park, N. J.*

PATCH, EARL S. (M) vice-president, sales manager, Moraine Products Co., General Motors Corp., *Dayton, Ohio.*

PRICE, HARRY (A) patent attorney, Bijur Lubricating Corp., 250 West 54th Street, *New York City.*

SARDOU, CHARLES, JR. (J) junior engineer, Stearman Aircraft Co., *Wichita, Kan.*

SHAVER, W. A. (M) sales engineer, Warner Electric Brake Co., Beloit, Wis.; (mail) 523 Sunset Road, *Ann Arbor, Mich.*

SISK, PAUL H. (J) engineer in charge of design and production, Wichita Falls Motor Co., *Wichita Falls, Texas;* (mail) Box 990.

STIVERS, HARRY LEE (A) division motor-vehicle superintendent, Bell Telephone Co. of Pennsylvania, Wilkes-Barre, Pa.; (mail) 41 North Walnut Street, *Kingston, Pa.*

SULLIVAN, W. B. (A), vice-president, general manager, Michiana Products Corp., *Michigan City, Ind.*

TALIAFERRO, LINDSAY CAVE (J) service-station department, lubrication sales promotion, Standard Oil Co. of New Jersey, *Baltimore.*

TEEL, R. M. (A) division superintendent, transmission and axles, Reo Motor Car Co., South Washington Avenue, *Lansing, Mich.*

TIMOSHENKO, STEPHEN (M) professor, engineering mechanics, University of Michigan, *Ann Arbor, Mich.;* (mail) 2007 Washtenaw Avenue.

VICKERS, JOHN (M) manager, aviation division, Standard Oil Co. of Pennsylvania, 1266 Ledger Building, *Philadelphia.*

Automotive Research

(Concluded from p. 107)

protection against vapor lock is desired on idling after a long run with the average of the makes of car investigated, at 90 deg. fahr. atmospheric temperature, the gasoline used must have a vapor pressure of less than 6 lb. per sq. in. These vapor pressures are very low and reflect seriously on the design of automobile fuel-feed systems which will permit the attainment of such high fuel temperatures. On the average, the temperatures found in the buses investigated were somewhat lower than those for the automobile fuel systems.

Detailed Report at Annual Meeting

A detailed report of this work will be given in a paper entitled, A Survey of Current Automobile and Bus Fuel-Line Temperatures, by Dr. O. C. Bridgeman and Elizabeth W. Aldrich, to be presented at the forthcoming Annual Meeting of the Society.

In the paper by Edgar, Hill and Boyd, previously quoted from herein, the authors make the following concluding statements regarding the vapor-lock research conducted by the Cooperative Fuel-Research Steering Committee:

It is clearly desirable, from the standpoint of the oil refiner and the general public, that as large as possible a fraction of the products of refining shall be available for automobile use, since this involves economy of manufacture and conservation of natural resources. It is also just as clearly desirable from the standpoint of the automobile manufacturer that his product shall operate satisfactorily on as wide a range of fuel as possible.

The oil refiner may contribute his part to increasing the permissible range by eliminating propane from his gasoline, and should, of course, provide a fuel whose 10-per cent points will lie between such limits as may be satisfactory in a reasonably well-designed fuel system. The automobile manufacturer may contribute his part by providing an efficient choke and by studying the temperatures reached in his fuel system and keeping them as low as possible by appropriate details of location, insulation, etc. The cooler the fuel, the less trouble from vapor lock, is axiomatic.

Applicants for Membership

The applications for membership received between Nov. 15 and Dec. 15, 1930, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

BEACH, HARRY L., Standard Oil Co. of New York, *Bristol, Conn.*

BOWLES, PERCY GEORGE, factory superintendent, Willys Overland Co., *Toronto, Ontario, Canada.*

BRUCE, ROBERT ARTHUR, managing director, Westland Aircraft Works, *Yeovil, England.*

BRAUER, ARTHUR C., design checker, General Motors Corp., *Detroit.*

BUTTERBAUGH, HOMER W., technical supervisor, American Brass Co., *Kenosha, Wis.*

CONNELL, CURTIS J., shop foreman, Rich Motor Co., *Greenwood, La.*

DENSE, ARTHUR F., superintendent, aircraft-engine division, Lycoming Mfg. Co., *Williamsport, Pa.*

DE THIERRY, ROBERT LEWIS HALL, foreign representative, Hardy, Spicer & Co., Ltd., Witton, *Birmingham, England.*

DEW, PHILIP HOLLADAY, assistant research engineer, Standard Oil Development Co., *Elizabeth, N. J.*

DIETER, WILLIAM LOUIS, aeronautical engineer, Sikorsky Aviation Corp., *Stratford, Conn.*

EARHART, ALBERT, manager of maintenance, Marmon Sales, Inc., *Denver.*

EBBERS, HAROLD L., sales engineer, Newton Die Casting Corp., *Detroit.*

FALLOWS, HERBERT, service manager, Studebaker Sales Co. of Boston, *Boston.*

HAIFTER, MITCHEL, graduate student in aeronautics, Daniel Guggenheim School of Aeronautics, New York University, *New York City.*

HANSEN, AUGIE L., president, general manager, in charge of engineering, A. L. Hansen Mfg. Co., *Chicago.*

HATELY, ARTHUR, *Pebble Beach, Calif.*

HILLBORN, HERBERT J., mechanical engineer, Koehring Co., *Milwaukee.*

HUXTABLE, LEONARD L., research engineer, Martin Motors, Inc., *Rutherford, N. J.*

JONES, ROWLAND, superintendent, Keystone Sand & Supply Co., *Pittsburgh.*

LANDGRAF, F., design engineer, Travel Air Division, Curtiss Wright Co., *Wichita, Kans.*

LAWLOR, JOHN CORNELIUS, 5134 Gatineau, *Montreal, Canada.*

LEA, SNOWDEN E., foreman, Keystone Aircraft Corp., *Bristol, Pa.*

LONGAN, JAMES A., manager, tank-car department, Island Export Co., *Baltimore.*

LONGSTAFF, G. E., production engineer, Rover Motor Co., Ltd., *Birmingham, England.*

MADGETT, CHARLES CHESTER, service manager, Reo Motor Sales Co. of Toronto, Ltd., *Toronto, Ontario, Canada.*

MEYER, LOUIS A., engineer and inspector, Institution of Aeronautics, *New York City.*

MUNOZ, JOHN ALBERT, Stewart Automobile Trade School, *New York City.*

OLTENBURG, HOWARD SESSIONS, manager tire department, Cochran & Celli, *Oakland, Calif.*

PANZEGRAU, NORMAN O., engineer, in charge of crawler tractor design, International Harvester Co., *Chicago.*

PERRY, FOSTER N., manager manufacturers sales, eastern district, American Bosch Magneto Corp., *Springfield, Mass.*

PHILLIPS, H. P., general superintendent, Climax, Jones & Quinn, *St. Louis.*

QUARNGESSER, ELWOOD S., co-partner, Warner-Fruehauf Trailer Co., *Baltimore.*

ROZMAN, FRANK, body draftsman, Fisher Body Corp., *Detroit.*

SAUER, HANS F., body die designer, Detroit Body Die Co., *Detroit.*

SCHERER, LEWIS F., mechanical engineer, Texas Pipe Line Co., *Houston, Texas.*

SCHWARTZ, EDWARD J., Detroit representative, Republic Rubber Co., *Youngstown, Ohio.*

SCLATER, ROBERT STEVEN, laboratory assistant, Texas Oil Co., *Bayonne, N. J.*

SMYTH, A. R., divisional manager, Imperial Oil, Ltd., *Regina, Saskatchewan, Canada.*

SPRUNG, EDWIN G., chassis engineer, Chevrolet Motor Co., *Detroit.*

STEARNS, CHARLES LEWIS, accountant, General Motors Export Co., *New York City.*

STIDHAM, JAMES, superintendent automotive equipment, City Baking Co., *Baltimore.*

TAYLOR, ARNOLD N., chief engineer, C. M. Hall Lamp Co., *Detroit.*

THOMAS, RAY J., layout man, Chevrolet Motor Co., *Detroit.*

VALLINGS, GEOFFREY HAROLD, chief assistant motor engineer, Shell Mex, Ltd., Kingsway, *London, England.*

VALENTINE, CLARE IRVING, student, University of California, *Berkeley, Calif.*

WALLER, D. D., designer and assistant experimental engineer, A. C. Spark Plug Co., *Flint, Mich.*

WILBER, DEL J., divisional sales manager, Robert Bosch Magneto Co., Inc., *Long Island City, N. Y.*

WILDMAN, CHARLES A., Diesel-engine design and experimental testing, *Warren, Ohio.*

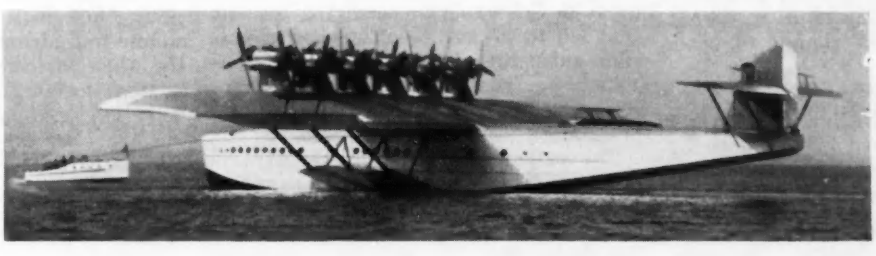
WILLIAMS, CHARLES GARRETT, technical secretary, Research Association of British Motor Manufacturers, *Chiswick, London, England.*

WILSON, E. A., president, Ingersoll Machine & Tool Co., Ltd., and vice-president, John Morrow Screw & Nut Co., Ltd., *Toronto, Ontario, Canada.*

WOLFE, LEON EVERETT, in charge of equipment, Lewis Mill & Timber Co., *South Bend, Ind.*

WORDEN, JOHN B., engineer, Atlas Imperial Diesel Engine Co., *Oakland, Calif.*

WORTHINGTON, S. P., president, Tiona Petroleum Co., *Philadelphia.*



Notes and Reviews

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor, *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

AIRCRAFT

An Investigation of the Phenomenon of Separation in the Air-Flow around Simple Quadric Cylinders. By John F. Parsons and Jarvis A. Wallen. Technical Note No. 354. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; 26 pp., 26 figures. [A-1]

The tests conducted at the Guggenheim Aeronautic Laboratory of Stanford University to investigate the phenomenon of separation in the air-flow past geometric bodies are described in this report. The experimental work consisted of wind-tunnel pressure-distribution tests and determinations of the line of separation on one circular and two elliptical cylinders. All three models had the same perimeter and were mounted in the tunnel so as to give two-dimensional flow symmetrical about the major axis. The speeds of test employed were approximately 40, 57, 72, and 91 ft. per sec. Theoretical pressure-distributions for the models were computed for purposes of comparison.

The tests show a recession of the line of separation and an improvement of the agreement between the experimental and the theoretical pressure-distributions with an increase in either fineness ratio or velocity. A given increment of velocity produces a constant recession of the line of separation regardless of fineness ratio. For each model, irrespective of scale, separation occurs after adverse pressures act through a constant distance. This distance, however, increases with fineness ratio.

The most important result of the investigation is the unique relation which was found to exist between the pressure at the point of separation and the minimum pressure. The ratio of these pressures, the pressures being reckoned from stagnation pressure as a datum, is shown to approximate 91 per cent and is independent of change of scale or fineness ratio.

Elements of Detail Design. By Frank Radcliffe. Published in *The Journal of the Royal Aeronautical Society*, November, 1930, p. 936. [A-1]

This is a constructive criticism of present-day aircraft design. The various problems of the aircraft draftsman are set forth and discussed. Standard specifications and their significance in detailed design; design of joints and fixings for primary structural members in general; choice of materials for design purposes to give maximum efficiency; and design economics and recommendations are all given due consideration.

The author aims to open up a discussion on this important aspect of aircraft design that will further the interchange of ideas and experience in detail design for the good of all concerned.

The Construction of Aircraft in Steel. By Major F. M. Green. Published in *Aircraft Engineering*, October, 1930, p. 249. [A-1]

Wood was the principal material used in airplane-wing construction until 10 years ago. At that time the need was felt for a material that is more durable and more uniform in its properties. This was the impetus that led various research departments to experiment.

Major Green, chief engineer for Armstrong Whitworth Aircraft, Ltd., gives in this paper some of the reasons that led to the choice of steel as a possible substitute for wood in wing construction; for example, reliability, resistance to fatigue and great resistance to damage from accidental knock.

The author gives in detail the experiments and tests upon nickel-chromium, carbon, and stainless steels, which have been carried on in the last 10 years. He feels that the results are most encouraging, for now it is possible to produce airplanes which show greater reliability than has ever been obtained with aircraft constructed of wood.

Anweisung für die Prüfung der Eigenschaften von Flugzeugen. By Walter Hübner. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Oct. 28, 1930, p. 529. [A-1]

The German Institute for Aeronautical Research sets forth in this technical note directions for qualitatively determining the characteristics of an airplane. It is intended to assist test pilots not particularly well versed in aerodynamics in their determinations as to whether a craft is likely to meet the airworthiness criteria of the type test.

Nine features of construction and operation are dealt with. The first is accessibility for examination, renewal or repair of such parts as are of prime importance in the routine flight, such as the carbureter, spark-plugs, radiator, fuel tank and oiling system. Second is the comfort and safety of the pilot's cabin. Controllability in ground operation is next considered. The criterion of balance is the ability of the airplane to remain in horizontal flight with free controls when the engine has been throttled down to 15 per cent of its maximum speed. Methods of testing dynamic stability in three directions are set forth under the fifth heading. Ease of control, maneuverability, spinning characteristics and the susceptibility of the structure to the setting up of vibrations at critical speeds or under critical air forces complete the list.

Vibrations de Torsion des Vilebrequins et Vibrations de Flexion des Pales d'Hélices. By Joseph Geiger. Published in *L'Aéronautique*, November, 1930, p. 403. [A-1]

After setting forth briefly the theories of torsional vibration in a crankshaft driving a propeller, the author describes the torsiograph developed by him. This is an instrument for recording crankshaft torsional vibration. He gives an account of its operating methods, especially its adaptation for high-speed conditions, and reproduces diagrams obtained with it from automobile and aircraft-engine crankshafts. He then distinguishes between true torsional vibration and crankshaft vibration arising from the action of the propeller or from the vibration of the aircraft itself transmitted through the propeller hub, and shows how his instrument can be used for the study of such phenomena.

The Care and Maintenance of Aircraft. Edited by Lieut.-Col. W. Lockwood Marsh. Published by Airways Publications, Ltd., London, 1930; 112 pp., Price, 3s. 6d. [A-2]

This book is a reprint of a series of articles published in *Aircraft Engi-*

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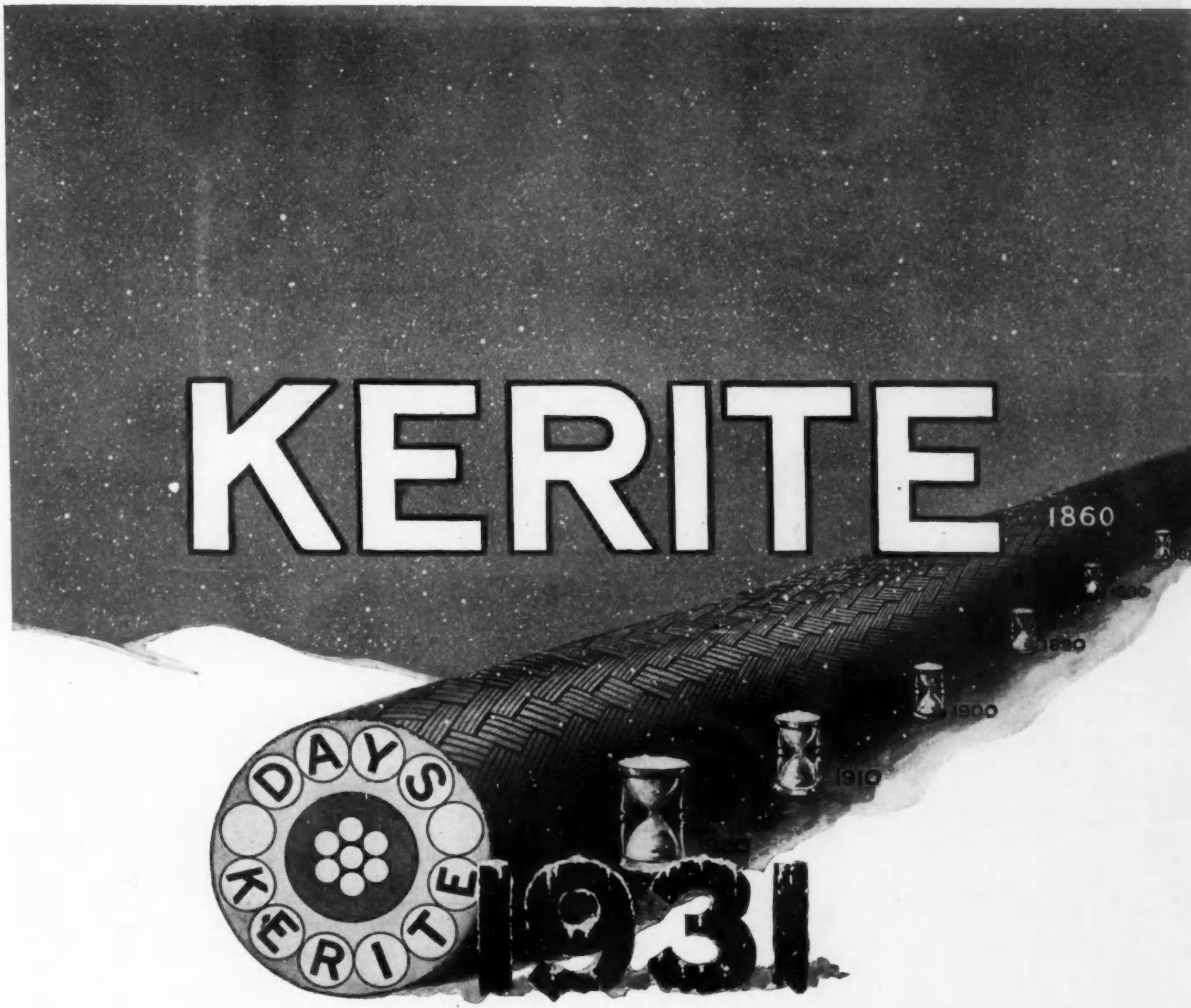

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Notes and Reviews

Continued

neering, which were written to provide a source of information for ground engineers and others who desire to become competent to overhaul every part of an airplane and its engine to make it fit for service.

The contents are arranged so that the reader, starting with the aircraft itself, can learn the complete process of the original assembly, erection, and checking of alignment of his machine, and then proceed to the points to be looked for in routine daily overhauls.

Instructions are given for top and complete overhauling of the engine, and how to install, check and calibrate instruments and maintain them. In conclusion, valuable information is given concerning the characteristics, treatment and testing of various materials, including steels, alloys, timber, glue and fabric, from which the plane and engine are built.

German Commercial Air Transport. By Martin Wronsky. Published in *The Journal of the Royal Aeronautical Society*, October, 1930, p. 849. **[A-3]**

Major Wronsky reviews German civil aviation and the formation and administration of the Luft Hansa A.G., of which he is general manager. He points out that the utmost concentration is necessary to assure progress, and that international cooperation is imperative, because of the keen competition between aviation and other forms of transportation.

He discusses at some length the problems with which present day aviation has to contend: absence of comfort in passenger service, unpunctuality, maintenance, insurance, administration, ground organization, night service, and postal and goods traffic.

On the question of safety the author laments the sensational reports of aerial accidents and points out that they were as numerous in the early days of the railroad. As the program for the future is world service, attention should be given to the building of capable freight and postal airplanes for the transatlantic traffic.

A Radiobeacon and Receiving System for Blind Landing of Aircraft. By H. Diamond and F. W. Dunmore. Published in the *Bureau of Standards Journal of Research*, October, 1930, p. 897. **[A-4]**

The system described embraces three elements to indicate to the pilot the position of his aircraft as it approaches and reaches the instant of landing. Lateral position, that is, landing-field runway direction, is given by a small directive beacon of the same type as that employed for guidance on the airways, differing only in the use of smaller loop-antennas and lower power. Longitudinal position along the runway, that is, approach, is given by a marker beacon. Height is given by an inclined ultra-high-frequency radio beam, which is used in such a way as to provide a very convenient gliding path for the landing airplane, free of all danger from obstructions.

The same medium-frequency receiving set required for obtaining radio-telephone and radio range-beacon service on the airways is utilized for receiving the runway-localizing and marker-beacon signals. The course indications of the runway-localizing beacon are observed on the same vibrating-reed indicator as is employed on the main radio-range beacon, automatic control of receiving-set sensitivity being provided to maintain substantially constant reed deflections regardless of the distance between airplane and transmitting station. The marker-beacon indications are received aurally. A special high-frequency receiving set is required to receive the landing-beam signals. The rectified output current of this set is passed through a direct-current microammeter mounted on the instrument board. By keeping the deflection of this microammeter at a fixed value, the pilot directs the airplane along the curved path coinciding with the line of equal intensity of the received signal

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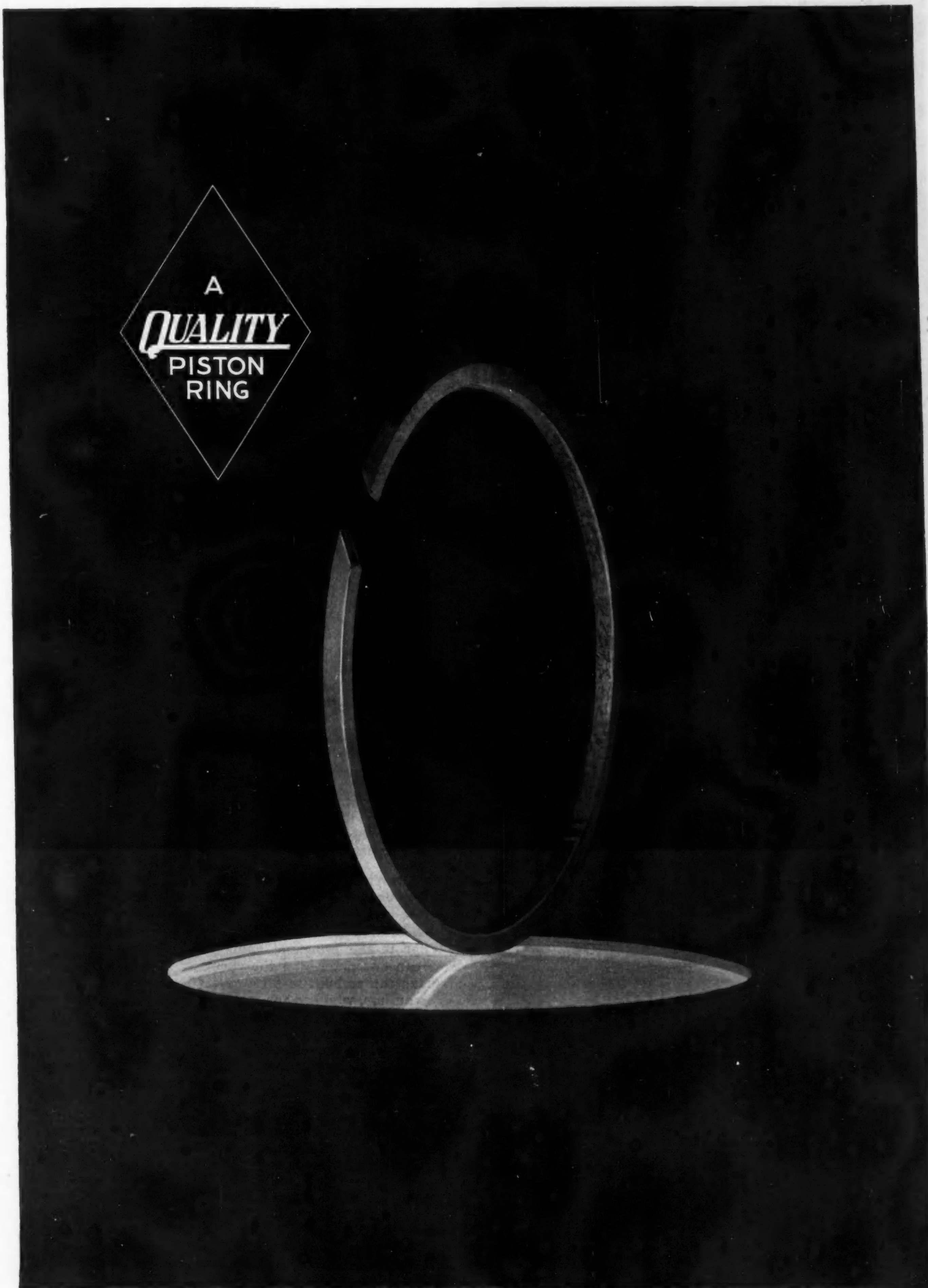
A
QUALITY
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Notes and Reviews

Continued

below the axis of the beam. The relative position of the airplane with respect to this convenient landing path is indicated by the rise or fall of the microammeter deflection above or below the fixed value.

Statistical Studies of Aircraft Accidents and Forced Landings. Air Corps Information Circular No. 652. Published by the Chief of the Air Corps, City of Washington, 1930. [A-4]

The general conclusions of this study are that

(1) Nearly all accidents and forced landings are due either to personnel error or to materiel failure, both of which can be considerably reduced.

(2) This reduction can be accomplished without sacrificing Air Corps effectiveness but, on the contrary, improving it.

(3) A reliable knowledge of the accidents and forced landings on the part of each individual will result in a general reduction of these occurrences.

(4) This knowledge on the part of commanding officers, operations officers and others will result in improved supervision and in the formulation of such directives and correctives as are required to further reduce these occurrences.

(5) Still further improvement will follow more detailed statistical studies of the underlying causes of accidents and forced landings, and the benefits thus attainable fully warrant greater care on the part of all concerned.

Gluing Wood in Aircraft Manufacture. By T. R. Truax, Technical Bulletin No. 205, United States Department of Agriculture, City of Washington, 1930. [A-5]

Glue is used not only in the laminating and building up of large and irregular wooden parts and in the making of plywood but it also affords the principal means of fastening the various wooden parts together into the finished structure. Joints, together with fastenings, are, however, generally regarded as the weakest part of the built-up structure. Consequently they control the design to a large extent.

The properties, durability and preparation of glues for use in aircraft; preparation of wood for gluing; gluing technique as related to the quality of glue joints; gluing different species and surfaces of wood; drying and conditioning glued stock; recommended practice for the principal aircraft gluing-operations; principles of cross-banded and laminated wood construction; and glue formulas for use in aircraft are a few of the topics discussed.

Über die Wirtschaftlichkeit in der Fertigung der Verschiedenen Bauverfahren von Flugzeugen. By H. Herrmann. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Nov. 14, 1930, p. 553. [A-5]

What is the economic value of an aircraft structure? How can one determine the cheapest method by which an airplane can be built to fill a given field?

The author, who has for many years been associated with the building and testing of aircraft, presents in this article his conclusions on airplane production costs, after 2½ years of consideration and classification of the information gained in his practical experience. He confines his discussion to airplane types commonly used and to those of less than 25 tons gross weight.

He first considers the material, then the form and construction of the various parts and finally the influence of the size and type of craft as a whole. He concludes, among other things, that monoplanes are cheaper than biplanes of like construction, that all-metal construction is considerably more expensive than composite construction, and that every additional precaution for reliability and safety adds to the production cost. However, viewing the subject only in an economic light, the fact that increased reliability means increased marketability must also be considered in conjunction with this last conclusion.

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Notes and Reviews

Continued

BODY

The Future Trend of Automobile Design. Presidential address by Sir Herbert Austin before the Institution of Automobile Engineers, England. [B-1]

Fashion often limits automobile progress as in other spheres and imposes conditions in the matter of design which are not always permanent or advantageous. Its demand for an enormous, long hood that is altogether out of proportion to the rest of the car keeps pushing the rear seat farther behind the rear axle, making riding less pleasant. If still lower bodies were to be the fashion, front-wheel drive might become an important matter. A certain amount of difficulty caused by taking the drive through the steering knuckles could be done away with by placing the engine in the rear.

One of the leftovers of evolution from the horse-carriage days is the separate construction of the body and chassis, which makes the vehicle considerably heavier than it need be. Because of this extra weight and the additional work entailed, the cost is appreciably increased. The author is convinced that the weight of all road vehicles could be advantageously reduced.

Study of individual wheel suspension has been held back, Sir Herbert states, by the improvement of road surfaces. There is also room for study of front-wheel springs, transmissions, shock-absorbers, Diesel engines and other elements. A more rational practice in design is just a question of time, Sir Herbert concludes.

Die Theoretischen Grundlagen für die Beurteilung und den Bau von Kraftfahrzeugkippern. By Karl Beneke. Published in *Automobiltechnische Zeitschrift,* Sept. 20, p. 621; Sept. 30, 1930, p. 650. [B-1]

The fundamental principles governing the operation of tipping mechanisms for dump bodies for motor-trucks and trailers are here set forth. Such factors as the force required, the load, the tipping angle and the time consumed are considered and the correlation between them worked out. Criteria are set forth for judging the mechanical efficiency and suitability of such mechanisms. Base performance-values for hand and engine-operated devices are given, and, by comparison with these, merit ratings can be assigned to any particular mechanism under investigation.

CHASSIS PARTS

Les Garnitures de Freins et d'Embrayage. By M. Destoumieux. Published in *Journal de la Société des Ingénieurs de l'Automobile,* November, 1930, p. 1154. [C-1]

In this study of the fundamentals of brake design, attention is focused on the factors influencing the interaction between brake-shoe and drum, to the exclusion of questions affecting brake-pedal pressures, hook-up systems and the distribution of braking force among the four wheels.

The first section of the article deals with the general characteristics of braking systems and the determination of the braking couple as a function of the various factors on which it depends. The criteria of brake performance set forth are the amount of braking force available in proportion to the effort put forth; consistency of operation, with freedom from irregularities due to faults within the mechanism; and uniformity of operation without regard to temperature or wear effects. A systematic study such as this, states the author, has for its aim to fix reasonable manufacturing tolerances and inspection methods for the materials employed.

The factors affecting braking torque are classified as geometric, under which heading shoe and drum design are

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considered; mechanical, including drum distortion, the flexibility of the different parts in contact, and their vibrating characteristics; and physical, such as friction and heat dissipation. The author points out that, while variation in braking force is most frequently attributed to variation in the coefficient of the brake-lining, it is often attributable to the other factors analyzed. Uniformity of dimensions, assembly and material of the brake system is recommended as the remedy.

In the second section of his article, the author takes up the nature and characteristics of friction materials, and, in the third, the qualities that a brake-lining should possess. The source of brake-lining troubles is said to be the difficulty of obtaining uniformity of quality in large-scale production.

Théorie Nouvelle sur les Trains Épicycloïdaux et les Mouvements Relatifs. By P. Ravigneaux. Published in *La Technique Automobile et Aérienne*, 4th quarter, 1930, p. 97. [C-1]

The theory of epicyclic gears and their relative movements here presented is an elaboration and clarification of design methods presented by the author 20 years ago. He deplores the neglect of this type of gear train, which he says constitutes an exceedingly flexible and useful mechanism, and attributes its lack of popularity to the difficulties that hitherto have attended its design.

For the method now developed, the advantages of simplicity, directness and absolute certainty of correct results are claimed. According to this, the designer can limit his study to the non-epicyclic movements of the mechanism under consideration and, for the transposition to epicyclic movement, can make use of certain simple formulas. In addition to the mathematical, a graphical method is presented, which is said to enable the problem to be solved without mathematical calculation, to indicate the choice of its conditions to accomplish the desired result, and to show relationships that cannot be expressed in formulas. Practical examples are worked out as illustrations of the methods.

Special Furnace to Heat-Treat Axles and Gears. Published in *The Iron Age*, Oct. 16, 1930, p. 1061. [C-5]

New equipment consisting of a two-chamber gas-fired furnace, an electric furnace and a cleaning unit has been installed in the axle division of the Eaton Axle & Spring Co., of Cleveland.

Rear-axle shafts are normalized, hardened and drawn in three gas-fired furnaces in line, two of which are fired with natural gas. The conveying mechanism of the three furnaces is arranged so that adjustments can be made for variation of production of 30 to 120 pieces each hour.

Alloy-steel gears and pinions are carburized in a two-chamber gas-fired furnace and hardened in an electric furnace.

Other interesting features of the installation are the suction system for cleaning carburized parts and a special process for removing oil and scale.

ENGINES

The A.E.C. High-Speed Airless-Injection Engine. Published in *Engineering*, Nov. 7, 1930, p. 584. [E-1]

The Associated Equipment Co., Ltd., of Southall, Middlesex, England, is constructing motorcoaches fitted with 95-hp. airless-injection engines of its own make. This engine has a detachable head and overhead valve-gear, and the fuel pump, of the Bosch type, is mounted on a bracket bolted to the timing-gear case. The main-bearing bolts are brought up through the top of the crankcase to form the anchorage for the cylinder block. The cylinder-heads are detachable

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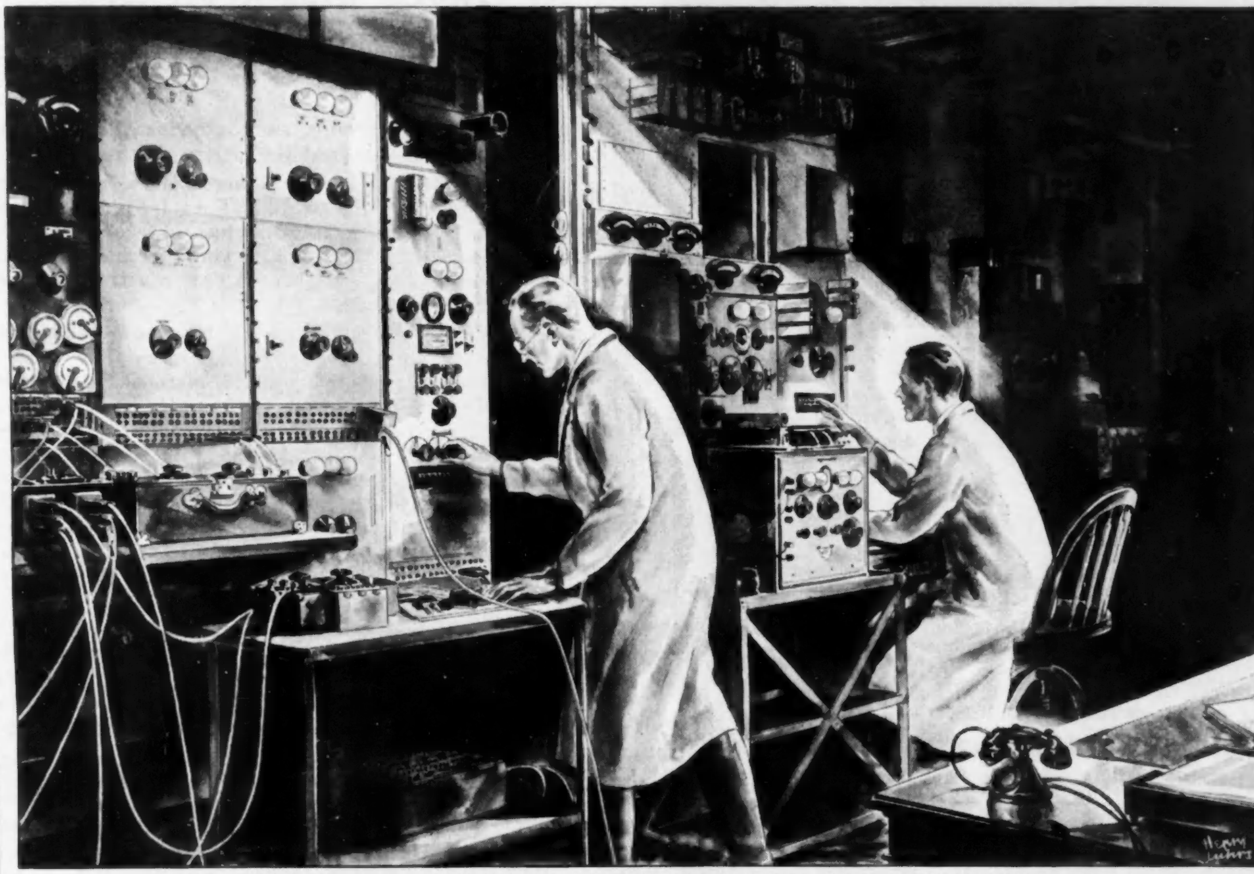

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and are made in two groups, each covering three cylinders. Other interesting features of the engine are given in detail.

The engine, complete with all accessories, weighs about 1350 lb., giving a weight of 14 lb. per b-hp. at the rated horsepower of 95. The speed range obtained in service is from 300 to 3000 r.p.m. and is much greater than that of any similar type of engine so far constructed. It is fitted to a Majestic chassis.

Consumption figures obtained for the same vehicle with the new engine and with a gasoline engine show that the consumption of the gasoline engine increases as the load decreases, whereas that of the oil engine first decreases slightly and, after remaining virtually constant over a considerable range, increases as the load is further reduced. Its consumption at quarter load is slightly higher than one-half that of the gasoline engine, and, as the average load is probably about 40 per cent of the full load and the oil consumption at this point is about 60 per cent of the gasoline consumption, the cause of the substantial saving is evident.

Effect of Orifice Length-Diameter Ratio on Spray Characteristics. By A. G. Gellales. Technical Note No. 352. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; 14 pp., 9 figures. [E-1]

The effect of variations in the ratio of orifice length to diameter on spray characteristics was determined for a 0.014-in. and a 0.040-in. orifice for ratios of 0.5 to 4.0. The nozzles containing the orifices were mounted in an injection valve and tested with a plain stem and with a helically grooved stem. The injection pressure was varied from 4000 to 8000 lb. per sq. in. The density of the air into which the fuel was sprayed was varied from that obtained with a pressure of 60 lb. per sq. in. to the density obtained with a pressure of 250 lb. at room temperature.

The tests showed that increasing the ratio of orifice length to diameter with a plain stem in the injection valve causes the spray-tip penetration first to decrease, reaching a minimum between a ratio of 1.5 and 2.5, and then to increase, reaching a maximum at a ratio greater than 3.5. The spray cone-angle showed little change with variation of the ratio. With a helically grooved stem and a small ratio of orifice area to groove area, the penetration at first showed little tendency toward a minimum; but, as the time of injection is increased to 0.004 sec., the penetration reaches the minimum at a ratio between 0.5 and 2.0. As the ratio of orifice to groove area is increased, there is less tendency for a minimum penetration to occur between the ratios of orifice length to diameter of 0.5 and 4.0 up to 0.004 sec. after the start of injection.

Some Characteristics of Fuel Sprays from Open Nozzles. By A. M. Rothrock and D. W. Lee. Technical Note No. 356. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; 11 pp., 12 figures. [E-1]

The penetration and cone-angle of fuel sprays from open nozzles were recorded with the N.A.C.A. spray-photography equipment. The results show that, for injection systems in which the rate of pressure rise at the discharge orifice is high, open nozzles give spray-tip velocities and penetrations that compare favorably with those of closed nozzles. The spray cone-angle was the same for all tests, although open nozzles having different orifice diameters were used, and one nozzle was used both as an open and as a closed nozzle. In designing a fuel system using open nozzles, particular care must be taken to avoid air pockets; the check-valve should be placed close to the discharge orifice.

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Heavy-Fuel Engines. By A. C. Douglas Clease. Published in *The Autocar*, Oct. 31, 1930, p. 917. [E-1]

The attraction of the Diesel engine for use in road vehicles and aircraft lies in its ability to use cheap fuel, its low fuel-consumption per brake horsepower-hour, and the fact that the cheap fuel used is, in its liquid form, almost non-inflammable.

The author discusses in detail five very interesting heavy-fuel engines. The Packard Diesel aircraft engine has nine cylinders, is air-cooled and of radial type. Air is drawn into the cylinders directly through a valve in the cylinder-head. The fuel is injected by a separate pump for each cylinder and the pistons have a peculiarly shaped head, being recessed on one side for valve clearance and fuel injection, which also assists to produce turbulence. The Hesselman (Swedish) engine is not a Diesel. It is of the low-compression type, has six cylinders with separate fuel pumps for each cylinder, and employs heavy oil as fuel. Ignition is effected by an electric spark in the ordinary way, and the engine has the characteristics of the gasoline type.

Another interesting engine, developed in New Zealand, is the Edlin-Stewart. It is of the four-cylinder two-stroke type but embodies sleeve valves. Each cylinder contains two working pistons, one of which is of ordinary design while the other takes the form of a sleeve which moves outside of, and in the opposite direction to, the first piston, the two pistons being separated by a stationary sleeve.

The Companie Lilloise des Moteurs in France has manufactured an engine of the single-cylinder two-stroke type which has been fitted to a light-weight automobile chassis and has been run with success. An Invecta Diesel engine, of very modern design and construction, is manufactured by Aveling & Porter, Ltd., of Rochester, England, under Acro license. It is a four-cylinder overhead-valve engine with Bosch fuel pumps.

Several compression-ignition engines using heavy oil as a fuel have been operated successfully in commercial-vehicle chassis on the Continent, in Great Britain and in the United States.

Zur Bestimmung der Eigenschwingungszahlen von Kurbelwellen. By Karlhans Schlaefke. Published in *Automobiltechnische Zeitschrift*, Oct. 31, 1930, p. 725. [E-1]

The investigation described in this article was carried out in an attempt to find an explanation for the difference between the observed and the calculated values for the torsional vibration of a given crankshaft, the observed values being only about 80 per cent of the calculated. The experimental and mathematical procedure having been checked and found correct, the conclusion was drawn that in the latter the fundamental concept was incorrect or incomplete. The investigator decided that failure to include in the calculations the effect of the front-drive apparatus on the forward end of the crankshaft was responsible for the discrepancy and, taking this into consideration, brought the experimental and calculated results into harmony.

Les Moteurs Diesel d'Aviation. By C. Martinot-Lagarde. Published in *La Technique Moderne*, Nov. 1, 1930, p. 713. [E-1]

After reviewing the advantages and characteristics of the Diesel engine as applied to aircraft service, the author describes briefly, as examples of such powerplants in practical use, the Packard of America, the Clerget of France and the Junkers of Germany.

Examination of these engines led him to the conclusion that light-weight solid-injection Diesel aviation engines are beginning to emerge from the laboratory research phase into that of restricted production and practical aircraft test.

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In the characteristics of piston speed, mean pressures, power in proportion to displacement and weight, the Diesel engine is approaching the Otto-cycle gasoline engine. The slight increase in weight of the engine proper is said to be compensated for by the fuel economy. Supercharging, according to the claim here made, will lower the weight per horsepower by one-third and so level off the weight differences between the two types.

A gradual increase in the use of the heavy-oil engine is predicted, without the immediate or complete displacement of the present type of powerplant, which will continue for a long time to be used for the more important applications.

Die Berechnung eines Fahrzeug-Dieselmotors. By W. Haeder. Published by Richard Carl Schmidt & Co., Berlin, Germany; 144 pp.; illustrated. [E-1]

With this, the third of his handbooks on Diesel-engine design, Dr. Haeder approaches most intimately the interests of the automotive engineer. The present work deals specifically with automotive types, whereas the two previous books dealt with two and four-stroke heavy-duty powerplants.

The specific engine, the design of which is completely worked out, is a six-cylinder four-stroke-cycle solid-injection engine having an output of 90 hp. at 1300 r.p.m. Related subjects, such as accessories, fuels and lubricants, are dealt with as well as the constructional and operating features of the powerplant. Thirty complete working drawings and many smaller sketches illustrate the text. The theoretical fundamentals of the design are presented as well as the practical details, with the object of enabling the reader to design engines of other dimensions but of similar type.

The Townend Ring. By H. C. H. Townend. Published in *The Journal of the Royal Aeronautical Society*, October, 1930, p. 813. [E-1]

The Townend ring is a device for reducing the air resistance of an air-cooled radial engine. It can be added to the engine without completely enclosing the cylinders, either singly or collectively, in streamline casings of the conventional type, which usually render the engine inaccessible.

Tests of the ring are explained in great detail and illustrated with numerous charts and photographs; also, full-scale check tests are given, making a very thorough piece of research work.

The general inference from all this work was that, where excresence or interfering bodies give rise to considerable turbulence, the resulting drag can often be reduced by adding what is virtually a guide vane made of an airfoil having good deflecting powers.

The discussion which follows the paper is as interesting as the paper itself.

Auswuchttechnik und Schwingungsbekämpfung im Motorenbau. By W. Späth. Published in *Automobiltechnische Zeitschrift*, Oct. 10, 1930, p. 671. [E-1]

While the balancing of crankshafts is the main topic of this article, the author adds a supplementary note on other precautions against vibrations in engines that he has found necessary in his extended experience in balancing many types of crankshaft.

Two machines of similar construction are described, both making use of the magnetic field as an indicator of balance, one designed for static and the other for dynamic testing. The correct procedure for the use of these machines, which operate at fairly low speed, is outlined and emphasis is laid on the necessity of distinguishing between the characteristics of the crankshaft itself and those that might be superimposed on it by the machine or test methods. Equipment and methods for dealing with the additional problems attendant upon high-speed operation are next dis-

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cussed. A test platform for measuring the vibrations of the engine as a whole is described, and then the final step, the appraisal of chassis vibration due to engine operation, is explained.

Diesel-Engine Operation, Maintenance and Repair. By Charles H. Bushnell. Published by John Wiley & Sons, Inc., New York City, 1930; 285 pp. Price $3.50. [E-2]

The author of this book aims to give the reader some of the problems and a few hints that will aid in the operation and maintenance of a Diesel engine. The material is the result of experience, observation and study. The various methods of procedure are treated more in principle than in detail and must be modified to meet existing conditions.

The illustrations are numerous, simple and in many cases diagrammatic, so that they are easy to comprehend.

Crankshaft Machining Requires Diversity of Operations. By Athel F. Denham. Published in *Automotive Industries*, Oct. 25, 1930, p. 609. [E-5]

One of the results of pressure lubrication is that the crankshaft became a highly complicated part of the engine. Differences of opinion are prevalent concerning dynamic and static balance, the quantity of stock to be removed from the pins and cheeks, heat-treating, tool pressure, design of the shaft, relieving of inherent strains, accuracy of alignment, and so on.

Methods employed in crankshaft making from forging the shaft to honing and polishing the bearings, are mentioned.

Equipment has been developed for rigidly holding a crankshaft in alignment and index during quenching and subsequent annealing. Virtually all major crankshaft-forging producers now have equipment for centering and index-marking their forgings. Several methods are used for centering, to spin the shaft on its dead center and to locate the shaft in a fixture from the various crank-cheeks. The method to be used depends upon the type of equipment and the routing of the shaft through subsequent operations.

Some manufacturers rough-grind the end mains before pin-turning; others semifinish-grind the main bearings before roughing the pins; still others rough-grind the pins before the main bearings after an intermediate straightening operation.

Correction for distortion occasioned by rough-turning the pins and pin cheeks usually takes the form of straightening. This may be accomplished by recentering only or by both straightening and recentering and perhaps heat-treating, or roughing out the intermediate mains before straightening, or straightening before roughing the two center pins.

Different methods of finishing are used. One company floods the bearings with heavy oil when starting up; another runs its grinders an hour before starting; and still another, with a minimum of clearance in its grinder bearings, runs them quite hot.

The article is accompanied with pictures of the various types of machines used in these processes. The author discusses the materials and methods used by Cadillac, Packard, Studebaker, Pierce-Arrow, Chevrolet, Ford, Reo, Dodge and others in crankshaft manufacture.

MATERIAL

Progress Toward a Uniform Method of Measuring Detonation. By T. A. Boyd. Paper presented at the 11th annual meeting of the American Petroleum Institute, at Chicago, Nov. 12, 1930. [G-1]

This paper gives an account of the work done last year under the direction of the Detonation Subcommittee of the Cooperative Fuel-Research Steering Committee toward the

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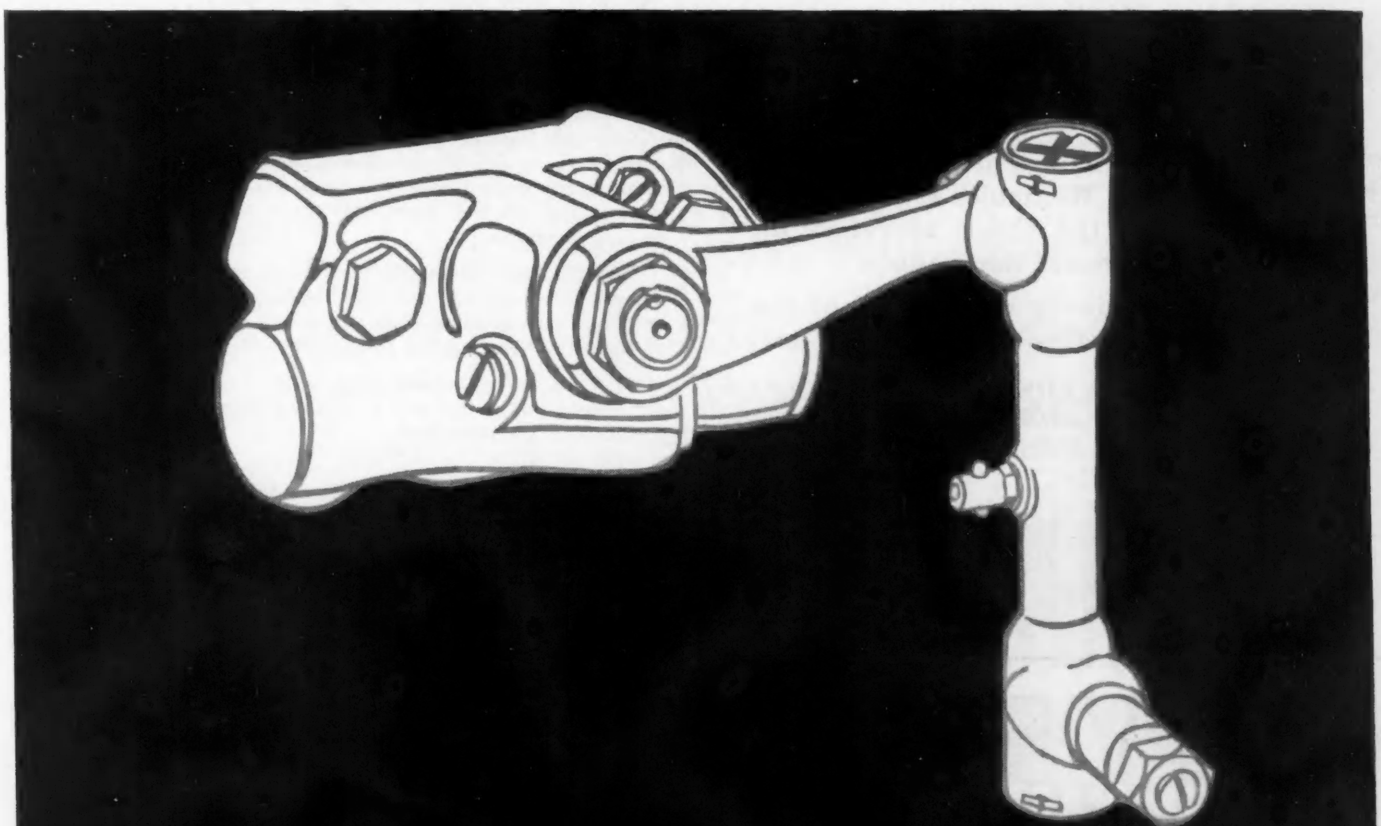

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establishment of standards of antiknock quality of motor fuels.

Apparatus has been developed to assure a uniform method of measuring the antiknock qualities of fuel. A reference scale has been tentatively settled upon by adopting as recommended practice the use of mixtures of normal heptane, a hydrocarbon of low antiknock quality, and iso-octane, a hydrocarbon of high antiknock quality. A large amount of experimentation has been done on the item of method, but no specific procedure has been adopted. The chief activity on method has been rather in the experimental evaluation of the outstanding variables such as spark-timing, mixture ratio, fuel consumption and the like, which influence the measurement of detonation.

The Meaning of the Gasoline Distillation Curve. By Graham Edgar, J. B. Hill and T. A. Boyd. Paper presented at the 11th annual meeting of the American Petroleum Institute, Chicago, Nov. 12, 1930. [G-1]

This paper contains no new information but is a very clear, simple summary of the Cooperative Fuel Research and its particular bearing upon automobile design.

The authors discuss the more important relationships between the distillation data of gasoline and its performance in the automobile engine. They believe that motor-fuel volatility is related to engine performance in the following ways: ease of starting a cold engine, tendency to interrupt operation because of vapor lock, ease of acceleration, relative ease of effecting a dry mixture, and tendency to crankcase-oil dilution.

If the A.S.T.M. distillation curve of a fuel is known, its characteristics with regard to all five of these factors can be at least approximately calculated.

The Technology of Woods Used in Aircraft Construction. By Forrest B. Fuller. Published in *Aviation Engineering*, November, 1930, p. 13. [G-1]

Strength values, strength properties and tests for determining these for the various species of wood used in aircraft construction are described and illustrated. A brief description of the standard types of machines used in testing is given.

The principal strength properties met with in aircraft design—tension, compression, shear, hardness, and static or transverse bending—are explained and the various types of tests for determining these are described in detail.

Conifers, or softwoods, and broad-leaved, or hardwoods, are discussed in the order of their importance in aircraft design and construction.

Aircraft Woods: Their Properties, Selection and Characteristics. By L. J. Markwardt. Report No. 354. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; 34 pp. [G-1]

Wood has been one of the pioneer materials in aircraft construction. Its salient qualities that have always enabled it to serve usefully are a high ratio of strength to weight; lightness, affording readily the size of member required to resist twisting and lateral buckling; ease of manufacture; facility of repair without specialized equipment and without highly skilled labor; and adaptability to small-scale production. Although a lack of uniformity in the quality of wood is perhaps the most important factor now militating against its continued use in present quantity production, the existing detailed knowledge of the properties and the causes of variation in them, determined at

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the Forest Products Laboratory and submitted to the National Advisory Committee for Aeronautics for publication, makes possible the selection of aircraft material with assurance and places design on a reliable basis.

Strength values of various woods for aircraft design for a 15-per cent moisture condition of material and a 3-sec. duration of stress are presented, and also a discussion of the various factors affecting the values. The toughness-test method of selecting wood is discussed and a table of acceptance values for several species is given.

This report also presents information on the properties of various other native species of wood compared with spruce, and discusses the characteristics of a considerable number of them from the standpoint of their possible application in aircraft manufacture to supplement the woods that are now most commonly used.

Methods for the Identification of Aircraft Tubing of Plain Carbon-Steel and Chromium-Molybdenum Steel. By W. H. Mutchler and R. W. Buzzard. Technical Note No. 350. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; 27 pp., 4 figures. **[G-1]**

The authors made a survey at the Bureau of Standards to determine a simple method by which chromium-molybdenum steel can be accurately and rapidly differentiated from plain carbon-steel. The methods surveyed in this investigation include hardness, magnetic-spark and chemical tests.

The conclusions based upon the experiments performed are that, of all the methods surveyed, spark testing appears at present to be the most suitable for factory use from the standpoint of speed, accuracy, non-destructiveness and reliability.

Investigation of the Thermal Conductivity of the System Copper-Nickel. By George F. Sager. Published by Rensselaer Polytechnic Institute, Troy, N. Y., 1930; 48 pp. **[G-1]**

The following conclusions are drawn from the results of the investigation reported herein:

The Lorenz ratio for copper is practically constant over the temperature range investigated—30 to 500 deg. cent. (86 to 932 deg. fahr.). The value obtained for nickel at room temperature is very nearly equal to that for copper, but the rate of its increase with temperature is quite marked. The values for the ratio and, in the case of nickel, its temperature coefficient are higher than those obtained by previous investigators. The ratios obtained for the alloys are higher than those for copper. They pass through minimum values in the neighborhood of 300 deg. cent. (572 deg. fahr.).

An Investigation of the Magnetic and Electrical Properties of Some Iron-Chromium Alloys. By Frederick Kapp Fischer. Published by Rensselear Polytechnic Institute, Troy, N. Y., 1930; 32 pp. **[G-1]**

The magnetic properties of iron-chromium alloys containing between 10 and 20 per cent of chromium vary widely with respect both to chromium content and heat-treatment received. Annealing produces the best magnetic properties. Baking the alloys at 500 deg. cent. (932 deg. fahr.) after annealing was harmful to the properties, as it reduced the permeability. Alloys in the range from 17.5 to 18.7 per cent of chromium were the best magnetic material. The effect of quenching on the magnetic properties is to reduce the flux density by a large amount and practically make permanent magnetic material out of the ring samples. The best alloy obtained was one of 18.7 per cent chromium. When annealed, this alloy has a maximum permeability of about 2000 at approximately 6000 gausses.

Personal Notes of the Members

(Continued from p. 117)

A. L. Doerr, who has been in Sydney, Australia, as sales manager for General Motors of Australia, Ltd., at its Sydney plant, recently resigned from the General Motors Export Division and is at present engaged in some private research and survey work.

Thomas L. Fawick is now president and general manager of the Fawick Mfg. Co., of Waukesha, Wis. He was formerly the head of the Thomas L. Fawick Co., of Akron, Ohio.

Benjamin H. Gilpin, who last year became service manager of the Pratt & Whitney Aircraft Co., of East Hartford, Conn., has been promoted to the position of factory manager.

It is announced that **L. H. Grisell**, who has been serving as chief engineer for the Scripps Motor Co., of Detroit, was recently promoted to sales manager. He will retain supervision of the organization's engineering activities.

Otto J. Groehn was recently elected vice-president and general manager of the Clayton & Lambert Mfg. Co., of Detroit, to which he returned after an absence of nearly six years, during which time he was serving the Hudson Motor Car Co. as superintendent of its Gratiot body plant in Detroit.

J. W. Grumme, Jr., who recently relinquished his position as superintendent of the carrier division of the New York Air Brake Co., of Watertown, N. Y., is now sales engineer for the Vacuum Oil Co., at Rochester, N. Y.

Augustine C. Haller, of Pittsburgh, was recently elected director and general manager of the Haller-Hirth Sailplane Corp., of South Hills, Pittsburgh.

Curt F. Hausser has been promoted to the post of chief inspector of the Waukesha Motor Co., of Waukesha, Wis. He had held the post of chief motor inspector for that company for 15 years.

Walter H. Himes is now manager of engineering at the Westinghouse Electric & Mfg. Co.'s Nuttall Works plant, at Pittsburgh, having been promoted from the post of consulting engineer at that company's East Pittsburgh plant.

Charles R. Horton, formerly layout draftsman and inspector of aircraft woods for the Spartan Aircraft Corp., of Tulsa, Okla., has relinquished that position to accept the post of production engineer with the Jackson Engineering Corp., also of Tulsa.

J. A. Howlett has resigned his position as lubrication engineer in the aircraft division of the Vacuum Oil Co., of New York City, and returned to Dallas, Tex., having accepted a similar position with the Magnolia Petroleum Co., of that city.

Cecil H. Hylton has been transferred from his post as sales and service engineer with the Karrier Motor Co., Ltd., of Huddersfield, England, and is now managing director for the Karrier Motors of South Africa, Ltd., of Johannesburg, South Africa.

Announcement has been made that **G. S. Ireland** has been elected president of the Terra-Marine Airplane Co., of Garden City, N. Y. He was formerly vice-president and director of sales for the Curtiss-Wright Flying Service, of New York City.

Harry V. Johansen, sales and experimental engineer, is now working as a general sales representative, with offices in the General Motors Building, Detroit. He was formerly sales and experimental engineer for the Jones Clutch & Gear Co., Inc., of Upper Sandusky, Ohio.

William L. Kaiser was recently appointed mid-west sales manager for the Wico Electric Co., of Springfield, Mass. His previous connection was with the Splitdorf Electrical Co., of Newark, N. J., which he served as central district manager.

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Supplement to S. A. E. Journal for January, 1931

Annual Meeting

S A E

January 19th to 23rd

Detroit

PROGR

S·A·E ANNUA

Monday ...... January 19th

10:00 A. M. *Crystal Room*

Standards Session

ARTHUR BOOR, *Chairman*

At the Standards Session, reports of Divisions will be presented and acted upon as usual

2:00 P. M. *Crystal Room*

Engine Session

ALEX TAUB, *Chairman*

Direct Air-Cooled Motor Car Engines
E. S. MARKS and CARL DOMAN, H. H. Franklin Mfg. Co.

Torsional Vibration Dampers
D. P. DENHARTOG and J. G. BAKER, Westinghouse Electric & Mfg. Co.

8:00 P. M. *Crystal Room*

Annual Business Meeting

PRESIDENT E. P. WARNER, *in the Chair*

Committee Reports

Standards Committee Report

Nomination and Election of Members-at-Large of Annual Nominating Committee

Announcement of Election of Officers for 1931

8:15 P. M. *Crystal Room*

Body Session

L. CLAYTON HILL, *Chairman*

Design and Color as Factors in Producing and Marketing the Motor Car
H. LEDYARD, Towle, Campbell, Ewald Co.

Business Session of Passenger-Car-Body Activity

Tuesday ...... January 20th

10:00 A. M. *Crystal Room*

Fuel Research Session

J. B. MACAULEY, *Chairman*

Comparison of Methods for Determination of Gum Content in Gasoline
O. C. BRIDGEMAN and E. W. ALDRICH, Bureau of Standards

A Survey of Current Automobile and Bus Fuel Line Temperatures
O. C. BRIDGEMAN and H. S. WHITE, Bureau of Standards

2:00 P. M. *Crystal Room*

Fuels and Lubricants Session

H. C. MOUGEY, *Chairman*

Oil Coolers and Oil Cooling
L. P. SAUNDERS, Harrison Radiator Corp.

Gasoline and Lubricants Produced by Hydrogenation of Petroleum
R. T. HASLAM, and W. C. BAUER, Standard Oil Development Co.

Classifying Transmission and Rear Axle Lubricants
C. M. LARSON, Sinclair Refining Co.

8:00 P. M. *Crystal Room*

Production Session

E. F. DUBRUL, *Chairman*

Machine Tool Obsolescence
L. A. BLACKBURN, of Detroit
(In Collaboration with J. W. BRUSSEL, Timken-Detroit Axle Co., and A. R. FORS, Continental Motors Corp.)

Torque, Thrust and Power Values for Practical Use in Drilling Cast Iron and Steel
O. W. BOSTON, University of Michigan, and C. J. OXFORD, National Twist Drill and Tool Co.

Business Session of Production Activity

Detroit **Book Cadill**

GRAM

AL MEETING

Wednesday . . . . January 21st

10:00 A. M. *Crystal Room*

Detonation Symposium

R. E. WILSON, *Chairman*

Effect of Humidity and Temperature on Octane Numbers of Secondary Detonation Standards
D. B. BROOKS, N. R. WHITE and G. C. ROBGERS, Bureau of Standards

The Cooperative Fuel Research Engine
H. L. HORNING, Waukesha Motor Co.

Influence of Carbureter Setting and Spark Timing on Knock Ratings
JOHN M. CAMPBELL, W. G. LOVELL and T. A. BOYD, Research Laboratories, General Motors Corp.

The Effect of Jacket Temperature and Cylinder Head Temperature upon Relative Knock Ratings
DR. GRAHAM EDGAR, The Ethyl Gasoline Corp.

The Effect of Knock Sound Intensity on Knock Ratings
H. F. HUF, J. R. SABINA and J. B. HILL, The Atlantic Refining Co.

The Effect of Oil Consumption and Oil Temperature on Octane Number Ratings
H. R. STACEY, Standard Oil Development Co.

Bouncing Pin Versus Throttle Audibility Method
NEIL MACCOULL, The Texas Co.

"Time Lag"
NEIL MACCOULL, The Texas Co.

Knock Rating
C. H. BARTON, Asiatic Petroleum Co., C. H. SPRAKE, Anglo-American Oil Co., and R. STANSFIELD, Anglo-Persian Oil Co.

Informal Discussion

Some Observations in the Detonation Testing of Aviation Fuel at High Temperatures
D. P. BARNARD, Standard Oil Co. of Indiana

(Continued)

Wednesday . . . . January 21st

(Continued)

The Effect of Engine Speed on Detonation
NEIL MACCOULL, The Texas Co.

Temperature Effects upon Anti-Knock Ratings
DANIEL ROESCH, Armour Institute of Technology

10:00 A.M. *Italian Garden*

Transportation Session

WARNER TUFTS, *Chairman*

Future Requirements of Motorcoach Operators
D. W. RUSSELL, Southwestern Transportation Co.

Future Requirements of Motorcoach Operators
JOHN B. WALKER, Greyhound Lines

Business Session of Transportation and Maintenance Activity

2:00 P. M. *Crystal Room*

Motor-Truck and Motorcoach Session

A. J. SCAIFE, *Chairman*

Future Requirements of Motor-Truck Operators
J. C. BENNETT, Associated Oil Co.

Business Session of Motor-Truck and Motorcoach Activity

8:00 P. M. *Crystal Room*

Aircraft Session

C. B. FRITSCHE, *Chairman*

The Economics of Ocean Airways, with Special Reference to the Seadrome System
E. R. ARMSTRONG, Armstrong Seadrome Development Co.

dillac Hotel **January 19 to 23**

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Thursday . . . . . January 22nd

10:00 A. M. *Crystal Room*

Aircraft Engine Session

C. L. Lawrance, *Chairman*

Fuel Injection with Spark Ignition in an Otto Cycle Engine
G. L. Williams, E. S. Taylor and C. Fayette Taylor, Massachusetts Institute of Technology

Increasing the Thrust Horsepower of Radial Air-Cooled Engines
P. B. Taylor, Wright Aeronautical Corp.

10:00 A. M. *Italian Garden*

Chassis Session

C. C. Carlton, *Chairman*

Rubber Problems Confronting an Automotive Engineer
R. K. Lee, Chrysler Corp.

Tires and the Rim Riddle
B. J. Lemon, U. S. Rubber Co.

The Development of Drop Center Rims
Charles Ash, Kelsey-Hayes Wheel Corp.

2:00 P. M. *Crystal Room*

Diesel Engine Session

O. D. Treiber, *Chairman*

Combustion Problems and Design of High-Speed Light-Weight Diesel Engines
E. F. Ruehl, I. P. Morris & DeLaVergne, Inc.

Operation and Maintenance of Diesel-Engined Motorcoaches
A. A. Lyman, Public Service Coordinated Transport

6:30 P. M. *Grand Ball Room*

Dinner

Detroit Section acting as host to the National Society

P. J. Kent, *Toastmaster*

James Schermerhorn, Jr., *Master of Ceremonies*

Address by Mayor Murphy of Detroit

Address by Mr. Vincent Bendix

Gulliver's Travels Among the Real Lilliputians of the Universe
Larry A. Hawkins, General Electric Co.

Tickets may be obtained in advance at Detroit Section Office. Price $4.00 each

Friday . . . . January 23rd

10:00 A. M. *Crystal Room*

Diesel Engine Session

W. F. Joachim, *Chairman*

Compression Ignition Engine Research
E. T. Vincent, Continental Motors Corp.

A Survey of Mobile Type Diesel Engines
C. G. A. Rosen, Caterpillar Tractor Co.

Business Session of Diesel Engine Activity

10:00 A. M. *Italian Garden*

General Development Session

E. S. Marks, *Chairman*

The Use of Zinc and Zinc Alloys in the Automobile Industry
R. M. Curts, New Jersey Zinc Co.

Riding Qualities
Dr. Fred A. Moss, George Washington University

Riding Qualities
Dr. Ammon Swope, Purdue University

Business Session of Passenger Car Activity

2:00 P. M. *Crystal Room*

General Session

Dr. Miller McClintock, *Chairman*

Safety Aspects of Car Construction
Robbins B. Stoeckel, Commissioner of Motor Vehicles for State of Connecticut

Inspection Trip

Through the courtesy of the General Motors Corporation a visit to General Motors Proving Ground, and to the General Motors Truck Company's Plants at Pontiac has been planned for Saturday, January 24.

Transportation facilities have been arranged and luncheon will be served at the G. M. Truck Co.

SESSIONS START ON TIME

Preprints of the various papers will, when available, be furnished upon request.